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EDITORIAL.

ITEMS AND NOVELTIES.

Heating and Ventilating Railway Cars.—We take pleasure in placing before our readers a system of heating and ventilating railway cars, which seems to meet the conditions of the problem upon more rational principles than various modes now practised. The plan referred to is that of Dr. J. G. Allen, of this city, and formed the subject of a favorable report, adopted at the last meeting of the Institute Committee on Science and the Arts. The heating is accomplished by a stove, of peculiar construction, placed beneath the platform at one or both ends of the car, which can be looked after by an attendant from the top. The products of combustion are carried off by an escape pipe, terminating above the roof of the car; and the heated air furnished by a cylindrical air-space about the fire box is led by tubes beneath the car, and supplied by openings at various points along its sides, slightly elevated above the

flooring. The ventilation is effected entirely from the bottom. Openings are pierced in several places in the centre of the aisle, through which the air escapes and is led off to a pipe terminating above the car in a cowl furnished with a flap-valve, which, while the car is in motion, protects the passage from the descent of the air current. The suction established at the free end of the cowl by its rapid passage through the air, is relied upon to produce an effective circulation of the air within the car.

The history of the process would then be about as follows: The heated air, upon its entry along the sides, rises at once (in virtue of its inferior specific gravity) to the top of the car, and is gradually forced downwards—escaping finally, with the exhalations of the passengers, through the ventilators in the flooring. The plan of ventilating apartments from the bottom has been so thoroughly established as the most economical as well as healthful, that if the mechanical details of the plan here described are as correct as the principle whose requirements they claim to meet, it cannot fail to meet with warm approval.

Road Steamers.—It is stated that during the recent severe weather, one of Thompson's road steamers carried on its regular traffic, under conditions which appear to be of great interest for Canada or Russia, where sledging is used as a necessary means of transportation. India rubber shoes do not slip on ice, and it has been found that by simply removing the steel guards from the India rubber tyres of the wheels, these engines can haul the heaviest loads over ice and snow without slipping. One of the engines was worked through a distance of three miles, daily, during the whole of the frost. Part of the distance has a rising gradient of 1 in 10, and the road steamer hauled a load of 7 tons up this incline when it was completely covered with solid ice. It is highly probable, therefore, that the steamers might be used in hauling trains of sledges with great success, and it is very possible that all kinds of traffic could be carried on with far greater ease and speed over the snow than over the ordinary roads.

A Veteran Steam Engine.—Our cotemporary *Engineering* gives the following account of a veteran engine, which possesses great interest in its bearing on the excellence of engine building during the early part of the century. At the establishment of Messrs. Frost & Son, there is now running a beam engine, built by the firm of Boulton & Watt, in 1811. The engine has a 36-inch

cylinder, with 6 feet stroke, and is run at the speed of from 18 to 20 revolutions per minute, the boilers in connection with it being worked at a pressure of 10 pounds per square inch. With the exception of about two years, this engine has been in constant use ever since its erection, and a considerable portion of the time it has been running day and night. Until within the last nine years the piston had gasket packing, and when metallic packing was then fitted to it, the cylinder was found to be perfectly true; notwithstanding the fact that it had been in use more than fifty years without having been bored out. The engine has short D slide-valves, driven by an eccentric, and some excellent indicator diagrams were taken from it a short time ago. The power indicated when the engine was doing its work was 53·4 horse-power.

A Band Saw Mill.—Richards, Kelly & Co., of this city, have just completed, for J. J. Van Pelt, Esq., of New York city, a band saw mill, of much larger proportions than any hitherto made, either in this country or abroad. The designs of Mr. Richards, of the firm, were submitted in January last, and the whole, including drawings and patterns, were built in about sixty days from the time of their approval. Mr. Van Pelt is one of the most experienced lumber manufacturers in our country, his yards being adjoining those of the French Band Saw Mills, at the foot of Tenth street, New York. It is to be presumed that he will develop many new features in this interesting problem of band sawing deep timber.

Some of the general dimensions are as follows:

Length of the blades	55 to 60 feet.
Width	5 to 6 inches.
Diameter of wheels	75 inches.
Lower shaft	4½ inches diameter.
Top shaft (steel)	4 inches diameter.
Range of guides	6 feet.
Total heights from foundation	about 24 feet.

The bearings are three diameters in length composed of, copper, 6, tin 1; being very hard, to withstand the strain of the saw, which will be from 1½ to 4 tons.

We expect to visit this mill after it is in operation, and to furnish a further notice in due time.

An Alloy for joining Brass with Steel or Iron.—The difficulty of finding a material suitable for permanently joining brass with steel or iron, on account of the unequal expansion of the me-

tals, is well known; and the information which Dr. Dingler offers us of an alloy possessing the properties requisite to insure a permanent adhesion, may possess some practical importance if its claims will stand the test of practice. The composition of the alloy is:—Tin, 3 parts; copper, 39½; and zinc, 7½.

Ernst Alban's Condenser.*—The following is a description and illustration of Ernst Alban's Condenser for high-pressure engines, taken *verbatim* from his translator. The extract is offered in the hope that it may prove of interest now, when studied in connection with modern ejector condensers, and with several patents lately issued for apparatus having like parts and use.—J. H. C.

Condenser for High-pressure Engines.—"A condenser is only advantageous for a high pressure engine under certain circumstances, and then it must be of the simplest construction, with no air-pump. This pump is fortunately not necessary when high pressure steam is used, as the steam blowing out from the cylinder may be made to act in its stead. The gain of the vacuum, where it can be simply obtained, is certainly worthy of consideration.

"The circumstances under which a condenser may be favorably adapted to a high-pressure engine are:

First. "When there is an abundance of cold water at hand, without requiring much trouble or cost to obtain it.

Second. "When the engine is very large, and the gain by condensation consequently more important.

Third. "When the steam blowing out from the engine cannot be used for any useful object. This does not often happen, for there are few engines where there are not at least rooms to be heated, or water to be warmed, or something of the kind, which will give a greater advantage from the waste steam than the application of a condenser.

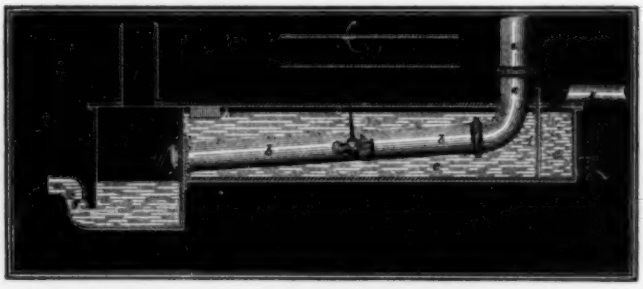
"The condenser for a high-pressure engine may be either with or without injection; in both kinds the water and air may be driven out by a blast of steam every stroke. The water should not be used for feeding the boiler, on account of the grease it contains. My condensers are in the highest degree simple, consisting only of a single pipe and a valve, with a small cock where injection is used.

Description of the Condenser.—"I have already spoken of the

* *The High-pressure Steam Engine.* By Dr. Ernst Alban. Translated by William Pole, C. E.: London, John Weale, 1848.

adaptation of a simple condenser, under certain circumstances, to the high-pressure engine.

An apparatus of this kind is shown in the annexed cut, in which *a* is the eduction pipe of the engine; *b* the condenser, a pipe of sheet-copper, the same diameter as the eduction pipe, and about twice the length of the stroke of the engine. It lies in a cistern, *c*, supplied with water from a pipe, *k*; *i* is a sieve, to prevent any particles of dirt getting into the part of the cistern from which the injection water is drawn, and *h* is an overflow, by which the waste-



water runs off; *l* is an emptying cock. The condenser is laid on an incline: the lower end projects out of the cistern into a box, *e*, and is furnished with a hanging or flap-valve, *d*, opening outwards. *m* is a small pipe, in which is fixed the injection-cock, *n*, turned by the key, *o*. The pipe is bent in the interior of the condenser, as at *a*, and has a mouth piece, *b*, so shaped as to spread the jet of water.

"The action of the condenser is as follows: At the moment the eduction passage is opened to the cylinder, the steam, having a pressure considerably above that of the atmosphere, rushes through the pipes, stops the injection, and blows the water and air collected in the condenser out at the valve *d*, into the vessel *e*. This, however, is but the work of a moment; the valve immediately falls, the jet of water again enters, and the steam is condensed. The air and vapor pass away from the vessel *e* by the pipe *f*, the water by the pipe *g*.

"I have only yet had opportunity of applying this condenser to two engines, both being single-acting, and used for pumping water. No barometer can be used with it, for obvious reasons, and therefore it is difficult to tell exactly the state of the vacuum. The best proof, however, of the efficiency of the apparatus is, that the engines,

even when they are in the most powerful and quickest action, will be stopped by simply closing the injection-cock.

"This condenser was one of my earliest inventions for the steam engine; it has been ascribed to others, but I made known a description of it about sixteen years ago; that is, about the year 1826.

Compounding Steam Engines.—The screw steamer Princess Royal has recently been lengthened 30 feet, and her original direct-acting inverted surface condensing engine has been *compounded* by placing two high-pressure cylinders on the top of the old ones, while two new cylindrical high-pressure boilers were also fitted on board. The old engines were not disturbed, and the alteration is so satisfactory that with an increased displacement of 300 tons, and the same speed, the consumption of fuel is reduced from 20 hundred weight to 11¼ hundred weight per hour. Vessels of the types generally built a few years ago can thus easily be altered to increase the carrying capacity, and at the same time reduce working expenses.—*Engineering.*

Speed of Telegraph Transmitters.—In conveying the Queen's speech by postal telegraph, the Morse printer was found capable of transmitting 40 words per minute. The Hughes type-printing instrument, which prints its messages in ordinary Roman type, sent 36 and 37 words per minute, but as no abbreviations are used, the speed is perhaps greater than in the Morse instrument where they are used. The Wheatstone automatic transmitter, where the messages are first punched out on a separate instrument, and afterwards passed through the transmitter proper, gave as the highest speed 94 words per minute.—*Engineering.*

Mechanical Engraving from Photographic Negatives.—In the interesting description of "Tilghman's process of cutting hard substances," by Mr. Coleman Sellers, in our last issue, the fact that printing from the bi-chromatized film could be accomplished in this surprising manner was mentioned. Since the article has appeared, Mr. Tilghman has devoted his time and attention to the development of this branch of his fruitful discovery, and with great success. We have been favored at his establishment with the opportunity of examining several specimens of his new art, which were sharp and beautiful reproductions from the negative.

A Monster Blast.—At the Bonaw granite quarries, Scotland, a mass of granite, computed by measurement to be about 800,000

tons, was displaced at one blast. The charge was about 8000 pounds gunpowder, and the preparation for the blast had been going on for about a year and a half.—*Engineering.*

The Bunsen Filter Pump.—In an elaborate paper of experiments, contributed by R. H. Richards, M. E., to the *Chemical News*, we glean considerable information concerning the conditions of greatest effectiveness and the relative advantages of various forms of this useful adjunct to the laboratory. The accompanying illustration shows a variety of forms which formed the subjects of the examination. In all the Figs. *a* represents the tube through which the air is drawn into the pump, and *f* that through which the water is fed.

Fig. 1 is the form designed and described by Bunsen, but the author finds much difficulty in adjusting the opening of the tube *p*, so as to give satisfactory results at different rates of speed. Fig. 2, in which the water flows through a tube of uniform bore, and the air is drawn through a small aperture in its side, is described as working very fairly. Fig. 3 is a simpler form of the same apparatus. As the chief object to be attained is to secure an even flow of air and water, that the tension in the vessel to be exhausted shall not be irregular but constant, Fig. 4 was devised, in which the air is made to bubble up through a little reservoir of water, *e*. It was found that by this device the air was naturally broken up into bubbles of very uniform size, and with much regularity Fig. 5 is a modification of this last, and possesses, with Fig. 3, the advantage of being simple in construction. With the glass blower's lamp at hand, they can be made in a few minutes by any one moderately

skillful. Fig. 3 is recommended for pumps ¼-inch or less in bore, and Fig. 5 for any larger than ¼-inch.

The data established by a number of experiments are stated by the author as follows:

1. The more water and the less air in the waste tube, the more tension.

2. Friction increases with the velocity of the flow, hence the slower the stream, the more the power.

3. The slower the rate of speed of feed water, the more power.

Lead Pipes as Water Conduits.—The influence of the metallic pipes in which water is conveyed to us, upon its healthfulness, is a matter of importance under any circumstances; but it derives especial interest just now, from the very extended attention which has recently been given to the subject by various municipal authorities. There exists a very widespread belief that water is very decidedly affected in its passage through leaden pipes—so much so, in many if not all cases, as to render the water injurious to the health. It has been abundantly proven, after faithful scientific investigation, that this view is erroneous; for there exist no authenticated accounts of the health of the numerous towns and cities supplied by leaden distributory tubes having been injuriously affected. The cause of this impunity, the English commission appointed to investigate this subject, find to reside in the extraordinary influence exerted by the small quantity of carbonic acid which the softest natural waters invariably contain. The effect of the presence of this gas is to convert the oxide of lead which may be dissolved into a carbonate, which is practically insoluble ($\frac{1}{6}$% of a grain dissolves to the gallon of water). In experiments made with the view of testing this point, it was found that pure water in contact with lead for twenty-four hours became highly poisonous, while, under the same circumstances, water containing 3 per cent. of carbonic acid remained perfectly safe.

There are, it is true, certain causes which may, to a limited extent (as in the supply of one or several dwellings), give rise to distressing accidents, such as the possible presence in the pipes of decaying organic matter, or other impurities. Such cases are, however, from their character, necessarily local, and cannot disturb the supply of a town.

The substitution of tin-lined lead pipe, block-tin or galvanised iron, have each been suggested in the place of lead, and each plan

has found warm advocates, and doubtless possesses certain advantages. It would seem, however, on examination of the subject, that while the introduction of either of these substitutes is attended with serious practicable objections, an appreciable superiority, in a sanitary point of view, is gravely to be doubted. Block-tin pipe, though very harmless, is by no means as durable as lead, being rapidly decomposed by limestone waters, and is, besides, too costly for this purpose, as the supply, even with its present industrial applications, cannot keep pace with the demand.

Tin-encased lead and galvanised iron pipes are likewise open to objections, which seem to more than counterbalance the advantages claimed for them. It is, in practice, impossible to protect perfectly the surfaces of metals with others. Under the most favorable circumstances, flaws in the coating will exist, and where these occur, we have all the conditions necessary for a galvanic current—(two metals in contact with each other and an exciting liquid)—an electro-chemical action takes place, whereby the positive metal is more rapidly decomposed and taken up by the water than if present alone.

It seems, therefore, established, that taking all the essential requirements, durability, cheapness and health, into consideration, lead, for water pipes, is to be preferred to any substitute which has as yet been proposed.

It may be curious to note, in conclusion, that, in the Report of the English Scientific Commission, which, upon investigation, declared in favor of lead, the purest water analyzed during extended examination as to the most available source from which to supply the city of London, came from a lake which received all the washings from neighboring lead mines.

At the last meeting of the Franklin Institute there were shown a number of new instruments imported by Prof. Morton for the Physical Laboratory of the Stevens' Institute of Technology. Among them were—

An Improved Pocket Chronograph, by Casella.—In size and form the chronograph precisely resembles a watch, and consists of an ordinary quick train lever movement, with the addition of a centre seconds-hand, which traverses the dial, as in a stop seconds watch, but differs from it by means of the registering property it possesses. This hand is therefore double, and is formed of two hands, one lying over the other. The

lower one at its extreme end has a small cup or reservoir, with a minute orifice at the bottom; the corresponding end of the upper hand is bent so as to rest exactly over the puncture. Having supplied this cup with a thin black fluid, formed of olive oil and a little lampblack, put on with the point of a pin, wind up the instrument in the centre hole at the back, and set the hour hand by applying the key in the second hole. The small catch beside the handle must now be pushed towards the handle, to put the work in motion. If using it at a race, on the first horse starting push in the stop in the handle, which causes the upper seconds-hand to dip through the orifice in the lower one, and leave a little black spot or speck on the dial. This is repeated as each horse or boat passes the winning post, so that an indisputable record is thus obtained by these dots of the exact time of arrival of each horse or boat, as well as the whole time occupied by the race. By this method the time may be taken to the tenth of a second without the confusion and anxiety of taking the eye from the object on which it is necessarily so intently fixed. The action, if continuous, is four hours without winding up, but it may be stopped at any time by shifting the side-catch back as above.

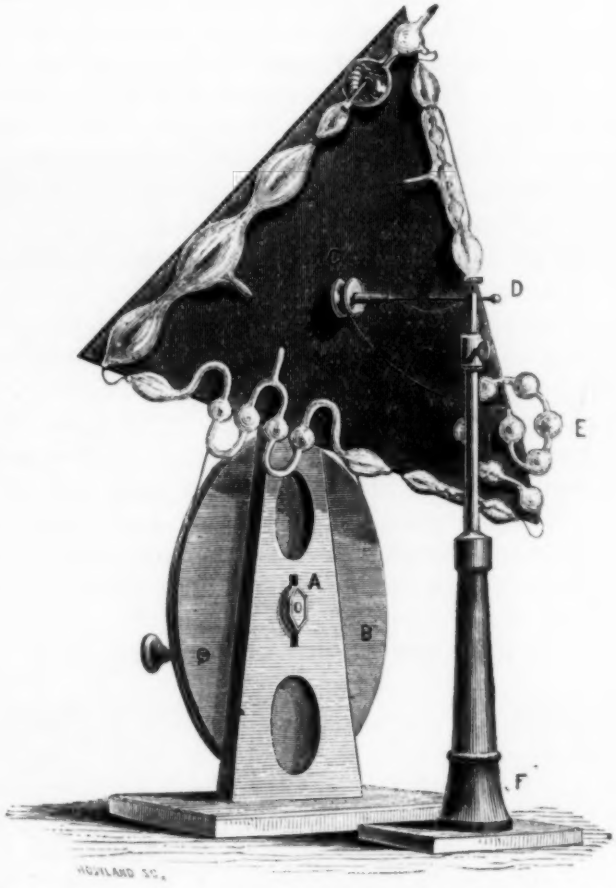
A Small Pocket Barometer (*aneroid*) by the same maker, of about the size of an ordinary watch, and capable of indicating heights up to 8000 feet, was likewise shown. This instrument indicates obviously the change in atmospheric pressure encountered in passing from one story of an ordinary house to another. Though this instrument is not capable of the same absolute precision as the standard mercurial barometer, yet for measuring ordinary changes in atmospheric pressure and for the rapid determination of heights, it is most efficient and valuable.

A Remarkable Spectrum.—An alcoholic solution of red aniline (fuchsine) containing 18·8 per cent. has a curiously varying refractive power for different rays. The index of refraction increases from Frauenhofer line B to D and slightly beyond, and then decreases very rapidly to G, from which line it again increases.

Frauenhofer line.	Index of refraction.
B	1·450
C	1·502
D	1·561
F	1·312
G	1·285
H	1·312

This gives a strange result on looking at an illumined slit through a sharp prism made of this solution; the colors are seen in the order, violet, red, yellow, the yellow being most deflected.

Gassiot's Electric Star.—The well known physicist to whom we owe the beautiful experiment of the electric cascade, also devised an arrangement by which the property of persistence of vision could be rendered available in multiplying and combining the beauties of those most fascinating of electric toys, the elaborate Geissler tubes.



His plan was to attach several of them to a system of radial arms capable of rotation, while the spark from an induction coil was passing through them. The successive flashes would thus find

them in different positions in rapid succession, and this with such quickness that by pe rsistnce of vision a kaladeioscopic repetition and combination of the figure would be obtained. This plan is admirable in its effect, and is only open to the objection that the apparatus is costly, and admits of but few variations. A modification made by Prof. Morton obviates both these difficulties. A sheet of card board is taken, of any desired shape, and a number of Geissler tubes being arranged on it in such figure as may be desired, the outlines of their prominent bulbs are marked, and then with a knife or punch corresponding holes are cut. The card has then a hole punched at the point which it is intended to make the centre of rotation, and is braced by having a few light strips of wood tacked to it in convenient positions. The tubes are then tied on with strings passed through small holes in the card. The card is then fastened by a screw button, C, to the front of an ordinary vertical rotating apparatus, A B, such as is used for a Newton's solar disk. A wire from one end, E, of the series of tubes is attached to this button, and from the other end, D, to a pin supported on a small rod of vulcanite from the centre of the same button. Opposite this is the adjustable pin of an insulated stand, D F, to which one pole of the coil is attached, while the other is led to the upper pulley of the machine. The cost of such an apparatus is very small, and at any time the tubes can be arranged in a different pattern on the same card.

Sensitiveness to Light of Ferrocyanide of Potassium.—A few experiments in the direction of utilizing the instability of this salt have recently been made public by Dr. Hermann Vogel. The fact that it is a decomposable substance is a matter of unpleasant experience with every chemist; that the cause of its alteration resides in the influence of light may not, however, be generally known, though Schönbein, as early as 1846, describes the phenomenon very accurately in *Pogg. Ann.* The fact may be verified by a very simple experiment, to wit: Divide a freshly prepared solution of the salt into two parts; place one in the dark and expose the other to the action of sunlight, and even in a few hours the last will be notably darker than the first preparation. The change seems to reside in the formation of the ferrocyanide, as may be proven by adding to the altered solution a few drops of sesquechloride of iron. According to Vogel, an exposure to sunlight for even 30 seconds is sufficient to detect the formation of some ferrocyanide, and this reaction he has endeavored to utilize in the

production of photographic images. The details of the trial, as described by the author in the *Ber. d. Deutsch. Chem. Gesell.*, are as follows: A paper was floated on a solution of the ferrocyanide, containing 10 per cent. of the salt, and was dried in the dark. This paper gave, when exposed under a negative for a short time, only faint traces of an image, which became, however, on immersing the paper in chloride of iron solution, very distinct, and of a strong blue color, from the formation of Prussian-blue. If, instead of using an iron solution, the exposed paper is immersed in a salt of uranium the corresponding compound of uranium is formed, which gives a picture of a pleasing brownish tint.

If a sensitived paper is exposed beneath a negative for a considerable time, a pale blue-black image finally appears, which is readily fixed by simple washing with water. At the close of this interesting communication the opinion is ventured that the cause of the instability of the numerous compounds at present conveniently [but very incorrectly—ED.] called spontaneously decomposable, resides, as with the ferrocyanide, in their sensitiveness to the influence of light.

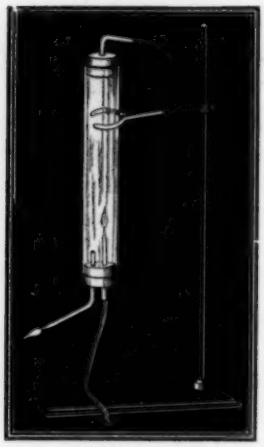
Occurrence of Saltpetre.—We lately received a number of samples of a thinly laminated sand-stone, from Tioga county, in this State, which were thickly covered, upon upper and lower surfaces, with a pulverant white coating. This proved, on examination, to be saltpetre. The statement accompanied the samples that it occurred in great quantity. In view, however, of the fact that our wet season is upon us, and that saltpetre is soluble, it appears extremely doubtful whether its stay in the county will be protracted beyond the month, even should the statement of its presence in quantity be literally true, which again is very doubtful.

A Lecture Experiment.—A number of devices, some of them simple, others complex, have from time to time been described, for showing the reciprocal combustion of the elements of water, and experiments of a similar nature.* Most, if not all of these, however, as will be found upon testing, either do not entirely remove the danger of an explosion from the operator, or they require the exercise of an unusual amount of care and dexterity to be used with success.

The accompanying arrangement, which is of the most simple cha-

* *Ber. d. Deutsch. Chem. Gesell*, III, pp. 419, 930; this *Journal*, LXI, 210.

racter, and which we saw for the first time on the lecture table of Prof. Himes, we have since repeatedly used to show the burning of oxygen, air, chlorine, &c., in hydrogen, burning gas or hydrocarbon vapors. The experiment can be performed with such ease that it is worthy of notice.



The arrangement consists of a cylinder of glass, about a foot or a foot and a half in length; (the kind used commonly as chimneys for the argand-burner can be had of proper length.) This is furnished, above and below, with a cork; the one at the upper end has one; that below has two glass tubes, of the form shown in figure. The whole affair is supported from the retort stand. The hydrogen (in the H and O experiment) is admitted through the upper tube, when it has completely displaced the air, is ignited below—(the cork having been removed)—and the supply is regulated until only a weak hydrogen flame remains. The oxygen, supplied through the straight tube in the lower cork, is now turned on slightly, and the cork fitted into its place. The flame of hydrogen at the opening is extinguished, but the oxygen, in passing up through it, is ignited, and burns now in the centre of the cylinder. The surplus of the hydrogen escapes now from the second tube below, and can be there ignited. This last flame serves the purpose of a good indicator, by which the supply of gases in the cylinder can be regulated, and which, of course, leaves the size of the flame at the will of the operator. Once in operation, the experiment may be left to take care of itself for the remainder of the hour.

Artificial Production of Coniin.—A late exchange gives us the intelligence of the artificial manufacture of the alkaloid coniin. This important discovery makes it very probable that we may yet be able to manufacture the valuable medicines quinine, morphine, and similar compounds, for the supply of which we are yet entirely dependent upon the vegetable world. The process of its manufacture is described to be as follows:—Alcoholic ammonia is allowed to act upon Butyric aldehyd at 100° C., the product of this action is combined with platinum and subsequently distilled. The pro-

duct of this distillation is an artificial coniin possessing all its chemical and physiological properties, and without in no way distinguishable from the natural alkaloid.

A Gas Furnace of Convenient Form.—Mr. Chas. Griffin has recently published an account of a very convenient form of gas furnace for fusions at white heat, the accompanying illustration of which we owe to the courtesy of the editor of the *Chemical News*. Its advantages lie in its portability, and in the fact that it does not require the aid of a blowing machine. It is stated that its heating power is sufficient to raise a 4½-inch crucible filled with metal to a white heat. We append a brief summary of its parts and construction.

Fig. 1.

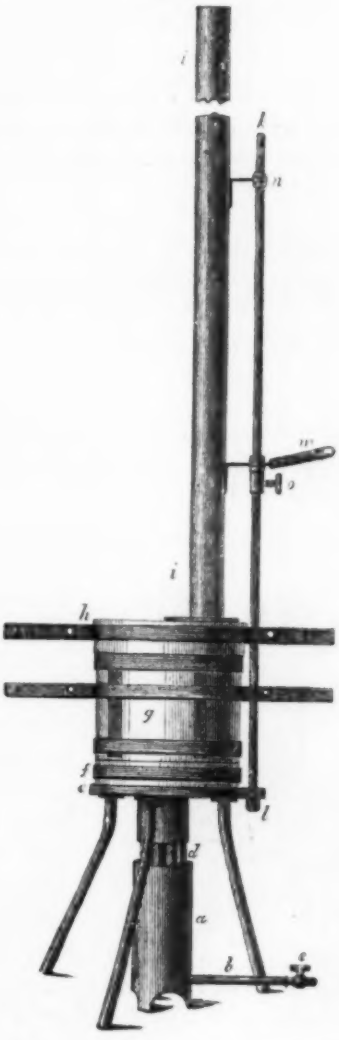


Fig. 1 represents the furnace,—height, including stool, 2 feet, external diameter, 8 inches. It consists of a brass cylinder, *a*, furnished with 16 Bunsen burners; *e* is the iron stand supporting the furnace and the iron rod, K, which holds the chimney. Fig. 2 shows the construction of *f*, the fire-clay sole plate, to the opening of which the burners are attached. *g* is a fire-clay cylinder—dimensions 6 inches height, 8 inches diameter and 5 inches bore. Figs. 3 and 4 represent a perforated black-lead cylinder to support the crucible C, which should be placed about 1 to 1¼ inches above the face of the burners. In Fig. 1 *h* represent the roof of furnace; Fig. 5 shows it in section. *i i*, (Fig. 1,) represent an iron chimney measuring 4 feet in length and 2 inches in diameter. The chimney is movable by

the handle, *m*. At *n* there is a guide and at *o* a stop, by which the chimney can be moved aside or adjusted with ease.

Fig. 2.

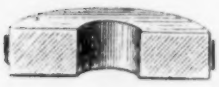


Fig. 3.

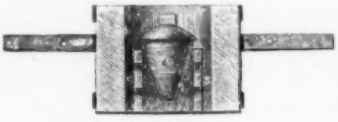


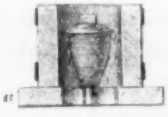
Fig. 4.

Figs. 6 and 7 represent respectively the form of grate and cylinder which have been best adapted for use with small crucibles. When the furnace cylinder, *g*, is replaced by an oval furnace body

Fig. 5.

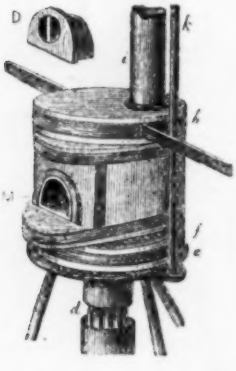
Fig. 6.

Fig. 7.



that contains a muffle as represented by *m*, Fig. 8, the usual muffle operations of cupellation, roasting of ores, &c., can be readily performed.

Fig. 8.



Operations that succeed at moderate temperatures, such as the fusion of zinc in an iron pot or ladle, are performed without using the dome and chimney. The vessel to be heated is to be placed on the inner cylinder of Fig. 3.

Access to the crucible in the furnace is gained at any moment by turning aside the chimney, and lifting the dome, *h*, Fig. 1. When the crucible is to be removed, the dome is first taken from the furnace, and placed on a circular plate of fire clay; the outer cylinder is next lifted off, and placed on a similar plate of fire-clay. The crucible can then be removed by the bow tongs.

Note.—A useful series of rules, formulæ, &c., for computing earthworks, by John Warner, we hope to be able to present in our next issue.—Eds.

Civil and Mechanical Engineering.

WOOD-WORKING MACHINERY.

A treatise on its construction and application, with a history of its origin and progress. By J. Richards, M. E.

(Continued from page 89.)

Mortising Machines.

MORTISES and tenons constitute about the only means of joining wood framing where the fibres meet at an angle. In metals the joining of the material is performed by melting and by fusion when a perfect union of two parts is necessary; but in wood work, joints have to be made by what we will term mechanical connection. Mortises and tenons in wood work can be regarded as representing bolted and welded joints in metal work. As the course of the fibre in wood is an important condition, and one which must be considered in the disposition of every piece and its shape, the framing of wood structure involves an intricate as well as interesting study for the engineer.

The extensive use of wood in buildings, bridges and other structures in the United States, has developed much in the art of wood framing. Some of these works have excited the wonder and admiration of the world. The trestle work on the Catawissa Railroad Bridge, of which there is a model in the museum of the *Franklin Institute*, is one of the boldest of these works in the country—not the boldest, perhaps, in the sense of braving danger, for some of the structures erected of timber during the late war, bear off the palm in this respect. The time and means considered, there is something almost marvellous in the feats of our army in bridging the Tennessee and other Southern rivers during the rebellion. Tenons and mortises are, however, only used for keeping the parts in place in such framing as it is now constructed; the whole being clamped and held by iron bolts that receive all lineal tension. In the shops mortises and tenons for furniture, joined work, carriage work, &c., are the common means of joining material. Machines for making tenons and mortises are therefore indispensable, and

rank in importance next to those for preparing material (planing and sawing).

Mortises are made by reciprocating chisels or by rotating tools; the first making finished rectangular mortises to receive tenons formed on the common tenoning machines, the second making mortices either on straight or curved lines, the ends being circular.

The first record of reciprocating mortising machines is that of Bentham, 1796, described in his patent of that date. He also describes the rotary mortising machine, and no doubt either himself or his brother made machines of both kinds, to be used in the English prisons about the close of the eighteenth century. Hand mortising machines, consisting of a chisel bar, worked by a weighted lever, came extensively into use in England forty years later, and are yet to be found in most of their wood workshops. The treadle machine is generally used in our country in places where there is no power used, and some kinds of mortising are performed on these machines even when power machines are at hand.

There is not in the whole catalogue of wood machines, if we except jig saws, a machine that has so long baffled inventors, and that has appeared in so many modifications, as the mortising machine. Like the jig saw, it is reciprocating, requiring greatest strength just where the least amount of material must be used, and liable to continual derangement from concussion. Machines in modern use can be classed into five modifications, exclusive of rotary mortisers.

1st. The graduated stroke machine, in which the chisel bar has a graduated reciprocating motion, commencing from a still point, and progressing downward into the timber, returning to the starting point at each return stroke—differing from a variable eccentric in the matter of requiring a stroke but little longer than the depth of the mortise. Variable cranks or eccentrics that operate the chisel bar by an increased throw, in both directions, above and below the *centres*, have been applied in all conceivable forms to mortising machines without any satisfactory result.

2d. Another class of machines are those wherein the reciprocating parts, including the crank-wheel, chisel-bar and connections, are all brought down towards the timber, the chisel having a continuous motion, with a uniform range and a fixed eccentric.

3d. We have the machines with the chisel bar or its connections elongated to give the stroke, the bar and chisel having a continuous reciprocating motion, but capable of being extended to the depth of

the mortise, and yet resist in its joints the force of the blow. The writer designed and patented, in 1866, a novel modification of this machine, wherein the operator was relieved from any jar or labor in operating the chisel bar, but at an expense of much complicated mechanism, that was inconsistent with the conditions of its operation.

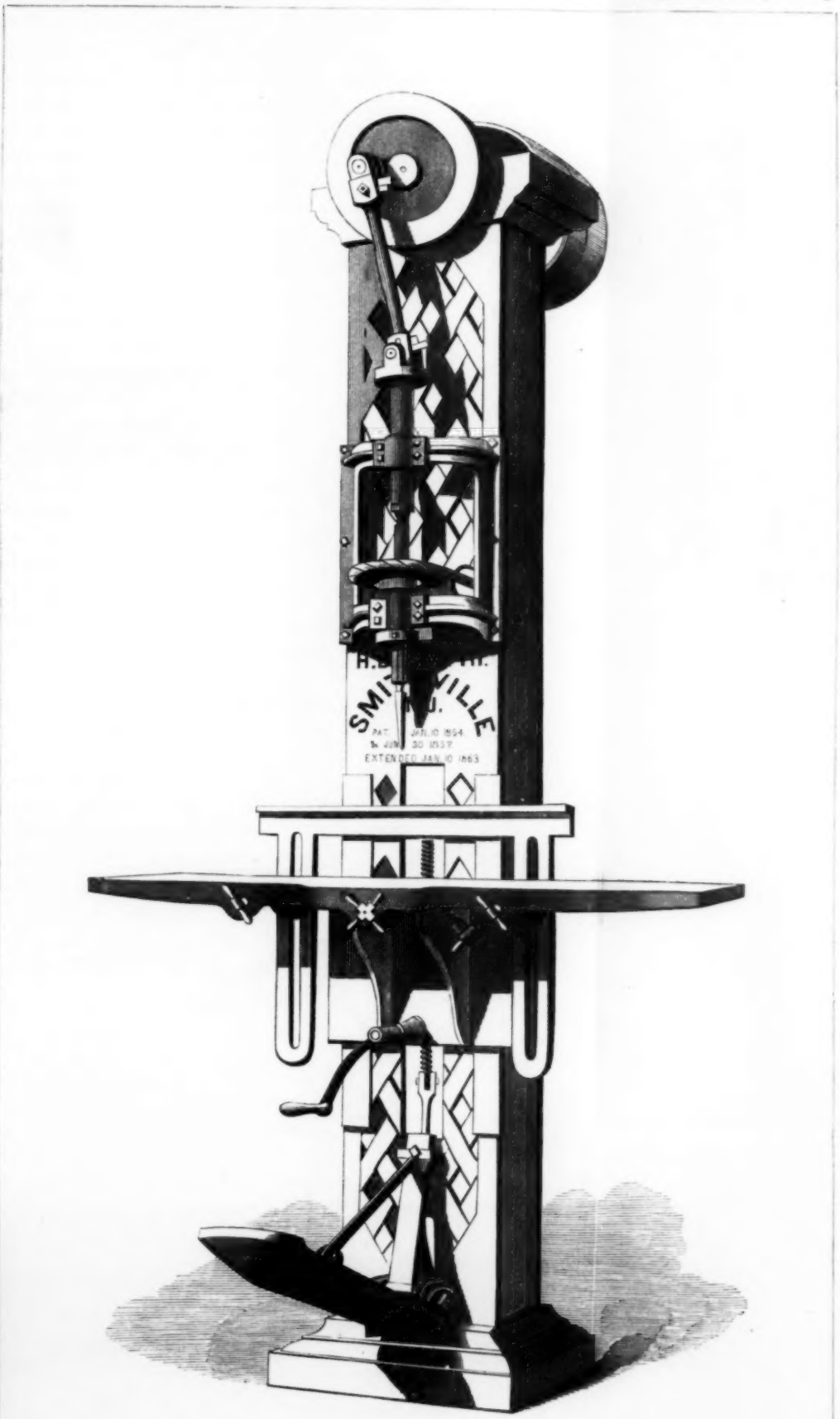
4th. Another modification is machines arranged to move or feed the wood to the chisel, which has a continuous reciprocating motion, the operating parts being only a crank-shaft, a plain chisel-bar, and connection. These machines are the most simple that can be constructed, and have every needed function for all kinds of work when the material is not too heavy to be raised to receive the action of the chisel. They can be operated at a speed that would soon destroy machines with more detail; and have superior claims, on account of their simplicity, for general uses. They can be operated at 600 blows per minute for joiner work, and when the bed or table is properly arranged, no inconvenience from jar is felt by the operator in raising the table. At a rapid motion the jar is absorbed by the inertia of the table (which is generally made heavy), and is hardly communicated to the treadle.

One of the most important improvements in power mortising machines which has appeared since the first conception of the machine, is the automatic reversing apparatus of H. B. Smith, patented in 1854. We say reversing device, for it is known by this name, and while it performed this function as its leading object, it also held the chisel bar firmly while in motion, and prevented any possible deviation of the chisel by loose joints or uncompensated wear, which was hardly second in importance to reversing the chisel to form the ends of the mortise. An illustration of this machine is shown in accompanying plate, which shows the machines as built by Mr. Smith, of Smithville, New Jersey. They are fitted with this automatic reversing device, of which we will attempt an explanation in general terms, so far as the principle is involved. There is maintained a constant torsional strain upon the chisel bar by means of frictional or yielding connection with the driving shaft by means of a belt that "slips" upon the pullies except at the instant of the rotation of the chisel. This belt is so proportioned and arranged, that while it offers no very great amount of resistance to the crank-shaft, it keeps a continuous rotary strain upon the chisel bar, which is released by stops at each motion of the table and allowed to per-

form a half rotation. These stops on the machine of Mr. Smith are so arranged as to allow the chisel bar to make one-fourth of a revolution during a movement of one inch of the table at its lower extreme, and another fourth during its ascent through the same distance, the chisel reversing its position at each motion of the table, without any care or effort on the part of the operator. This slipping or frictional contact with the continuously moving parts of the machine can be attained in various ways. A flat belt would, however, seem to be the best adapted to the purpose. Clutches having metallic faces would tend to abrade each other, and require elastic pressure. A polished metallic surface in contact with leather has, in this case, as in other places, proved itself as the best combination for frictional contact. The round belt, however, wears well, and this part of the machine never gives any trouble.

Automatic reversing devices of other forms have been applied, generally dependent upon the feed or table movement to revolve the bar—in some cases by direct contact of spiral extensions on the bar, which come in contact with a sectional nut. To revolve the chisel bar of a mortising machine by connection with the table movement must, of course, consume some share of such movement that cannot be utilized in mortising, as the chisel must be clear of the wood when reversed. To allow the bar to come in contact with any stationary part, when in motion, would only be admissable at a slow speed; while in both cases the keeping or holding mechanism that retains the bar in position when cutting, can be nothing more than a weak spring, whose force must be overcome continually in the act of reversing. These objections are only obviated by the use of some "extraneous" force, acting upon the chisel bar independent of the reciprocating or feeding parts of the machine, which this frictional connection with the crank-shaft gives in a very perfect manner.

Among the many improvements in wood machines by English manufacturers, the mortising machine has been "left out." Their idea of mortising seems to be gathered from the metal-slotting machine. The writer has seen and examined the machines of two prominent English makers, in both of which the chisel was driven to the bottom of the mortise at the first stroke: geared in one by positive clutches, while the other had no visible means of feeding the chisel down, except by starting the machine after setting the wood. Such machines would in this country be considered totally inoperative. Messrs. A. Ransome & Co., of London, are now pre-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paring patterns, and will soon produce wood mortising machines, under several modifications, to meet the various conditions of work, of which cuts will in due time be presented.

A fifth modification is the core-boring mortise machine, having a square hollow punch, bored cylindrically through its centre to receive a boring bit, the corners of the mortise being cut away by the punch or chisel; and the wood carried out by means of the screw-bit working in the punch. These machines have been very successfully worked on hard wood framing, at the "Lagonda Works," at Springfield, Ohio, where they were first applied to heavy work in this country. For mortising plane stocks and window sash, and other light work, they answer a good purpose, and avoid the vibration that is common to the reciprocating machines.

Fig. 1.

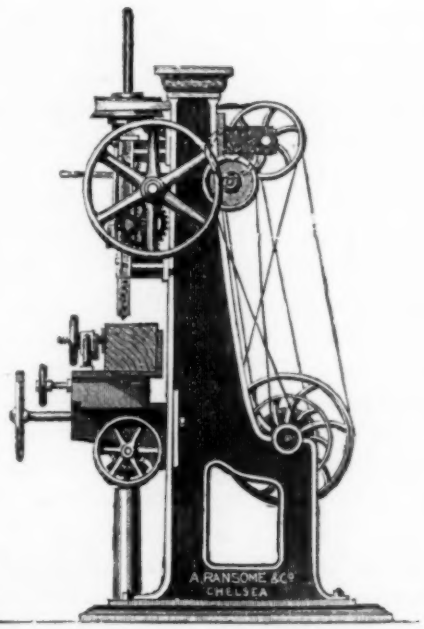


Fig. 1 is a side elevation, on a scale of $\frac{1}{2}\frac{1}{4}$th, of a mortising machine of this kind, from the designs of the manufacturers, Messrs. Allen Ransome & Co., of London. It is built of two sizes, weighing respectively one and one-half and two and one-half tons.

Rotary mortising machines have as yet, in this country, been confined to light work. It is safe, however, to presume that they will, in future, come more and more into favor for the heavier class of work. M. Perin, of Paris, France, makes a good machine of this kind, which is far superior to any thing of the kind yet made in this country.

(To be continued.)

THE SUEZ CANAL.

By Prof. J. E. Nourse, U. S. N.

Not unfrequently this work is still spoken of as of doubtful completion, and of yet more doubtful success. I offer the *Journal*, in this connection, a statement of facts from recent trustworthy sources, which may throw light on the question. The want of correct information on the part of many may be well understood when one remembers the looseness of the floating paragraphs from time to time appearing in the papers of the day, the admitted want of complete success at the date of the opening of the Canal, in 1869, and the supposed want of any important bearing on American interests by a work at so great a distance from us.

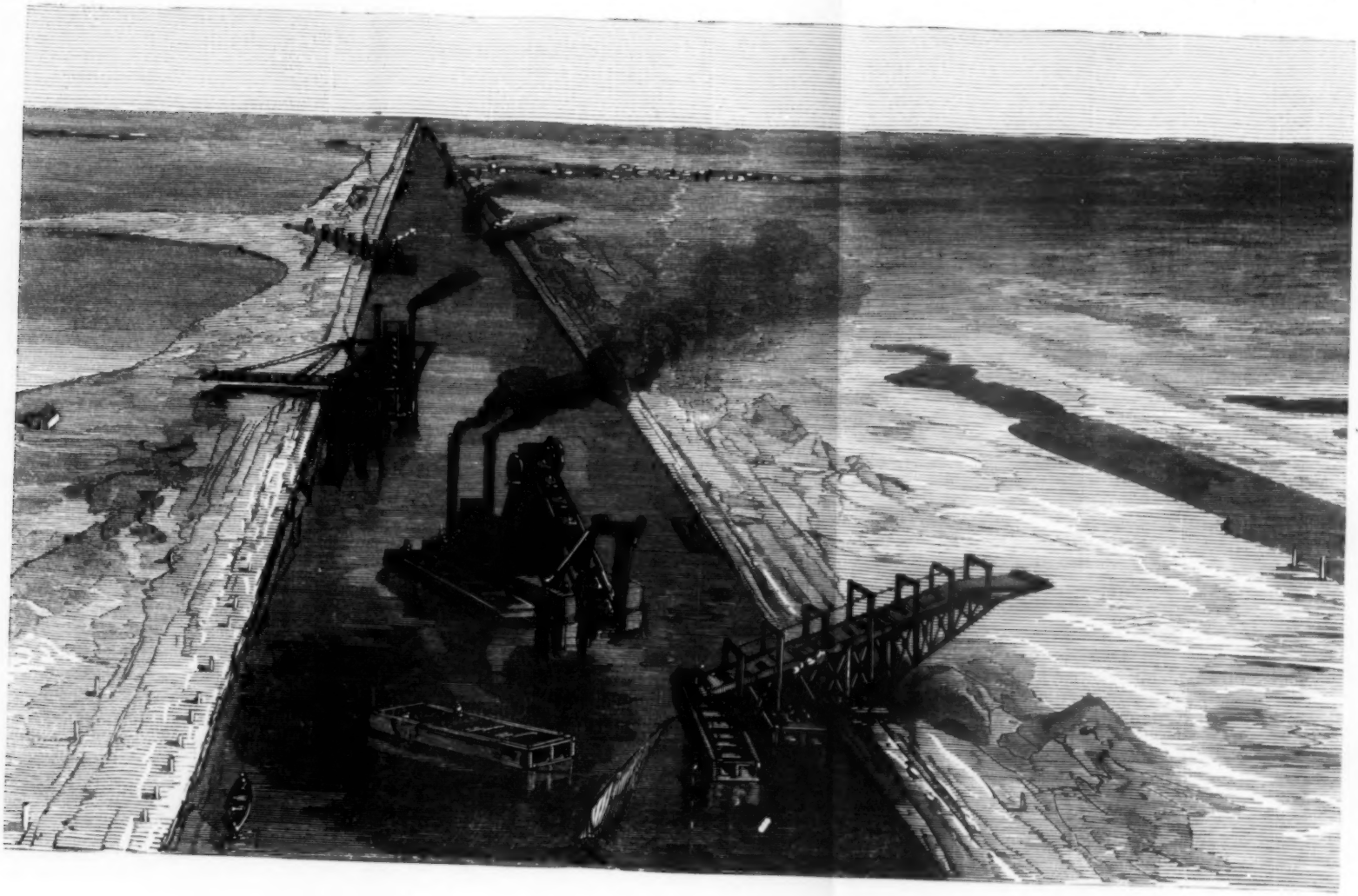
I say *supposed* want of importance to us; for it cannot be really difficult to discover that a route between Europe and the Indies, saving half the time and inconvenience for trade and travel, worked by British capital, and urging on as it does with increased activity that marvellous substitution of steam for sails and of iron vessels for wood that is going on all over the world—that such a route may have a very marked influence on American interests.

For the description of the Canal as a work of engineering, I must refer your readers to the *Engineer* and to the *Journal of the Institute of Civil Engineers*, or, more directly, to the lucid Reports of *La Compagnie Universelle*, the latest ones of which contain the plans and details of the contractors, Messrs. Borel & Lavalley.

For a short memoir of the perseverance of M. Lesseps, and of the progress and inauguration of the Canal, I may be permitted also to refer to a pamphlet* published last year, as the statements therein, are confirmed by the most recent authorities. It is worth noting that M. Lesseps' statements and promises, however flatly denied or disbelieved at the time by his English opponents, have proven themselves true, and are now acknowledged to have been such.

The Canal, according to the *London Times*, is "the event of the age;" and it is now quite pleasant for our English friends, who are getting it under the control of their money-power, to discover that Lesseps was not what they called him, the "false High Priest,"

* The Maritime Canal of Suez. J. E. Nourse, U. S. N. Philps & Solomon, Washington.



but a true Apollo. The freedom of London and the medal of the Royal Geographical Society are among his witnesses.

I now condense leading facts as closely as practicable.

1. *The line of the Canal.*—Port Said, on the Mediterranean, lat. 31° 3′ 37″, is joined by this route with the newly made city of Ismailia, on Lake Timsah, half way across; and with Suez, lat. 29° 58′ 37″, as its terminus on the Red Sea. The distance from the lighthouse at Port Said to Suez is 160 kilometres, about 100 statute or 88 geographical miles, of which 66 miles are actual canal, and 22 miles of the navigation are through the three Lakes, Timsah and the Bitter Lakes. Its breadth was originally planned to be of the following dimensions: the breadth to extend to 325 English feet, having a floor 72 feet wide in centre, with a depth of 26 feet, sloping up 2 to 1, till within 5 feet of the water surface, where the section is for 50 to 60 feet, either level or with horizontal benches, ending in slopes of 5 to 1. It was to have a water way, 26 feet deep for a width of 72 feet, 20 feet deep for 95 feet, and 15 feet for a width of 112 feet. By the Report of Commander Beardslee, of the U. S. steamer Palos, which passed through in August last, these dimensions (quoted from Captain Richards' previous Report to the British Admiralty) have been now secured. The *gares* or turnouts have been widened and deepened. The clayey nature of the dredgings and the coarse grass which has sprung up have made firm banks, high enough in most places to prevent more than the lighter sand from being blown over, while the amount accumulating in a year can be removed in a short time by the dredges. It is to the praise of the inventors of these powerful machines, Messrs. Borel & Lavalley, that this last statement is confirmed by a Report made to the Prussian Government in 1869, in which report it is said that one of these dredges could take out a year's accumulated sand "before breakfast." And, in passing, it may be stated that the largest are 110 feet in length, and of 75 horse-power, costing $100,000. Throughout the whole length of the Canal there is a telegraph, with a station and a Semaphore signal station at each *gare*.

2. *The Breakwaters at Port Said and Suez.*—The two jetties at Said extend into the Mediterranean 6940 and 6020 feet, enclosing an area of 450 acres, formed into a harbor of a depth in the ship channel of 25 to 28 feet. These jetties consist of blocks of concrete, of 22 tons each. Through the western pier—neither of them having been built solid—the current and westerly winds bring quantities

of silt, or deposit from the Nile, which is is gradually, though slowly forming a bank within; but this is looked upon as a benefit, in the way of an additional breakwater. It is proposed to extend this pier further into the Mediterranean, till it shall be over four miles long, as originally proposed by Hawkshaw.

A breakwater at Suez protects the Canal from southerly winds. The Egyptian government have a dry dock here, 416 feet long, with a width of entrance of 78 feet and a depth over the sill of 22 feet. One of the largest British frigates has been docked in it. The largest ships of the Peninsular and Oriental Steamship Company can lie alongside in the basin of the harbor.

3. *Approach to the ports and passage through.*—Capt. Richards, the British hydrographer, reports to the Admiralty that, under ordinary circumstances, the approach to Port Said presents no difficulty whatever; that the navigation of the Red Sea cannot be said to be dangerous, though tedious even for sailing vessels, and that the maximum speed in passing through the Canal should never, except in the Large Bitter Lake, exceed 5 miles an hour, on account of the safety of the vessel itself as well as of the banks.

The *charges* are 10 francs per ton, on registered tonnage (or exclusive of space occupied by engines and coals); 10 francs per head for passengers; and 20 francs for each 4 inches over 20 feet draught as a pilotage charge. The cost of the Canal, thus far, has probably exceeded $100,000,000; the amount of dredging has exceeded 100,000,000 cubic yards.

I will close these notes by quoting some of Captain Richards' Conclusions, reported to the Admiralty, and by showing their confirmations by recent passages made by large vessels.

In February, 1869, Captain R. used this language: (1) "For a certain class of vessels, this great work, which must always be a monument of persevering energy and *engineering* skill as it now stands, is a convenient mode of passage from the Mediterranean to the Red Sea.

(2.) "It will be so to a greater extent when the works contemplated are carried out, viz: the deepening of the shallow parts, enlargement of the gares, and widening of the curves.

(3.) "The cost of maintenance will not exceed the estimate made when the work was first projected.

(4.) "By a different construction of our transports, this highway will be used by them with ease."

In regard to these remaining defects, Commander Beardslee reported to the United States Navy Department in August following: "I learned that all the bad spots which existed in the Canal in February have been completed to the regulation depth and width, and my own observations confirm the most of the statements made to me about them. The steamer Delaware, 3293 tons, 380 feet in length and 36 feet beam, has safely passed." Commander Beardslee made nearly three hundred soundings on the passage of the Palos; he found, while these soundings were taken within the channel, a depth no where less than between 22 and 24 feet.

In further confirmation of the present state of the Canal, it may be enough to refer to any current number of the *London Times*, in which will be found shipping notices of the regular departures of more than thirty first-class steamers from London for Bombay, Calcutta and Japan by this route. Their tonnage varies from 1000 to 2200 tons. One of them, the "F. De Lesseps," is advertised as "under engagement with Lords of Admiralty for the conveyance of troops." The Austrian Lloyds are also advertisers of a line from Trieste to Bombay; "fare, £40, first-class." It is noticeable that the larger number of these vessels have been built expressly for the Canal route, and, as was to be expected, the number of sailing vessels advertised is almost crowded out by these steamers, although the clippers around the Cape advertise their having made the passage from Canton in 98 days, "the shortest of the season"—more than double, however, the time required by the Suez steamers. It is known, also, that an equal activity in the steam lines exists at Liverpool. The Canal is reported by the captain of the British screw steamer, the Magdala, recently arrived at New York through this route from China, as having everywhere a depth of twenty-four feet.

The passage of two of the largest vessels of the Pacific Mail Steamship Company is a fair test of the present state of the Canal. For the following returns of the measurement of these vessels, and of the passage of the Arizona, I am indebted to Mr. F. W. Bellows, of the Company's Office, in Wall street, and to Messrs. S. L. Merchant & Co., their shipping agents in New York. Messrs. Merchant are also the agents for the Coal Depots at Port Said, Ismailia, and Suez.

The Arizona has a length of 362 feet, depth of hold 30 feet, beam

46 feet. Her tonnage is 2790. She passed through the Canal successfully on the 26th and 27th of December last. Reaching Ismailia in ten hours from Port Said, she moored there at night, and was aided on her remaining part of the route by a tug, because of the high wind. The cost of her passage, including that of 126 tons of coal at 34 shillings per ton, was, in all, £955 1*s.* 8*d.*, a saving in the matter of coal and of wear of the vessel, as well as of time, very decidedly in favor of the Canal over the Cape route. The Alaska, of 4011 tons, is yet to be heard from, her departure from New York having been but recent.

The U. S. Consul at Malta, Mr. L. T. Adams, has kindly furnished a statement of the number, nationality and tonnage of vessels calling at the port of Malta on their way through the Canal during the year 1870.

From Consul Adams' registers at Malta, it appears that in 1870, 201 merchant vessels, with an aggregate of 168,068 tonnage, arrived and cleared from Malta for the Canal. To these he adds 14 men-of-war and troop ships, making an aggregate tonnage of 175,000. Their nationality is very marked. Of the 201 merchant-men, 197 were English. The facts are as striking in the statement, also furnished by the Consul, of the whole number of vessels which passed through the Canal in 1870. The entire tonnage was 444,211; the number of vessels 491, of which the British numbered 314.

It may be remarked that the tonnage of 444,000 would yield a revenue of but $888,000, at the tariff fixed by the original concession of the Canal, viz: 2 francs per ton. Increasing this revenue tonnage, by the tariff for port dues, pilotage, &c., to the round sum of one million of dollars, we have still a very inadequate return during the first year, so far as the original investment is to be considered. If, however, the canal revenues never repay the original patriotic stockholders, it will be nothing new in the history of all such enterprises. The question is, whether the saving in time, wear and expense offered to trade by this route—owning, too, as the Canal does, its dredges and large coal supplies—it will attract the full commerce of Europe.

The French political and commercial reverses are, at present, acting unfortunately on the route. The Government subsidy has been, of necessity, withdrawn from the French Messageries Imperiales Company. Notwithstanding all this, M. de Lesseps is quoted

from Paris as refusing to transfer the control of the Canal to British hands.

Is it likely that a shrewder judgment could be desired than that which we find in the *Times*, so long the uncompromising enemy of the Canal? In a leader of December 26, upon the Mt. Cenis Tunnel, that paper speaks thus:

"The Mediterranean promises to be again the chief highway of the world's commerce. The Mt. Cenis Tunnel and Suez Canal have a close relation. The far East is now certain to communicate with Europe by the Red Sea and the Mediterranean. Already passenger traffic passes almost wholly that way, and no one can say how much of the bulk of commerce may follow. Marseilles, with its new streets of grand and costly buildings, and harbors full of shipping, showing the revival of a decayed city by the commerce of this route, and Trieste, which has become the southern port of Central Europe, are, both of them, still behind Brindisi, in Italy, in advantageous position for communication with Port Said and Alexandria."

The Suez Canal, then, considered impartially from every point of view, as an accomplished fact, presents itself, to the engineer, the merchant and the historian, as one of the three events of the age: a grand monument of engineering skill; a conquest over nature, to open up intercourse and civilize the races of the East, long barred out by the desert;—one in the trio joining hands with the American Railroad and the Ocean Cable, to bind man to man.

CORNISH ENGINES.

By W. H. G. West, U. S. N.

(Concluded from page 180.)

On page 241, first paragraph, Mr. Birkinbine quotes, and questions the truth of a part of my paper upon the performances of engines, having reference to weight of moving parts, but he follows it, immediately, with a re-statement of the thing he is looking for. In the July number for 1868, page 34, Mr. Henderson says: "As a further proof of the advantage of a heavy moving mass, it has been found in practice that "Bull" engines are invariably inferior in duty to the beam variety, and that the latter description *vary in their duty in proportion to the amount of metal distributed in the*

moving parts. There are other statements of the same character, if Mr. Birkinbine thinks it necessary to find them.

Mr. Birkinbine's "valuable consideration," page 241, the possible high degree of expansion, because of immense weight, is singular, and perhaps entertaining, when we know that our best engine, that of the Easton Water Works, cut off at two-thirds ($\frac{2}{3}$) of the stroke, (March, 1870, page 156,) or expanded to one and a half ($1\frac{1}{2}$) volumes, while a rotative pumping engine of 32-inches diameter cylinder and 9 feet stroke, designed and built by the same engineer, was working in the Bethlehem zinc mine, and cutting off at 7 inches, or expanding to fifteen and a half ($15\frac{1}{2}$) volumes. The distances expanded through are one (1) of the Cornish engine to twenty-nine (29) of the rotative—29 to 1 against Mr. Birkinbine. This is my argument against excessive weight, in moving parts, to render a high degree of expansion possible.

In dealing with the portion of Mr. Birkinbine's paper which treats of steam jacketing, I beg permission to remind him that the *theories* of the gentlemen to whom he refers are built upon that splendid practice which so-called practical men are ever trying to approach. Ridicule of their perfections is no argument in favor of bad practice.

I have never heard of a steam jacket giving trouble, but it may be expected to do so in engines otherwise badly designed.

The vapor remaining in the condenser of an engine should not be over 90 degrees. The temperature will always be less than that which corresponds with the vacuum, as the latter is invariably impaired, to some extent, by the presence of the air which enters through joints and stuffing boxes, and with the water.

I do not agree with Mr. Birkinbine about his miracle, page 242. The man who made the experiment was not an engineer, as I understand the word, but he was one of the attendants who made the 130,000,000 with the same engine. The circumstance was related to me by the designer of the Easton engine. He had already profited by the lesson.

The second paragraph of page 240 states that few Cornish engines use steam above 45 + atmosphere.

On page 374, December, 1868, Mr. Henderson says, "Upon investigation I find that from sixty to seventy pounds of steam is not an unusual pressure used in the Cornish engine where a high degree of expansion is employed." ($\frac{1}{2}$?) In this instance Mr. Birkinbine is correct.

Immediately following the above Mr. Birkinbine asks a singularly strange question, "By maintaining a pressure *sufficiently* above this in the boiler to counteract the loss of heat from various causes in working steam, may not all the benefits of a jacket be secured in this way?"

All the heat in the sun could not do it in this way.

We admit steam for a moment; it is then cut off from the boiler, leaving no communication whatever; it is expanded, in an instance here given, over fourteen times; all the particles of steam expanding at the same time, and undergoing a reduction of temperature simultaneously. No one particle can superheat another without losing its own heat, or we have perpetual motion. The high-pressure steam must enter into the cylinder to produce any good effect. The expansion must be of a higher grade, and the condensation during expansion will be, therefore, greater. The condensation by radiation will be greater, because the difference of temperature will be increased. The leaks caused by unequal temperatures and the expansion of metals, etc., will be augmented. Leaks, such as that between the piston and cylinder, will be greater, and will increase much faster, by the use of high steam, and, generally, the losses will be multiplied to a great extent.

High steam, if not too high for the modifications imposed by imperfect practice, is more economical than low steam; but the above named, and other losses, increase with the pressure of saturated steam, and most of them with the temperature of superheated steam. A steam jacket reduces them to a minimum. High steam increases them to a maximum. If we fail to give them due consideration in designing, we do so much to diminish the duty or efficiency of the engine.

No point of superiority should be neglected, however small it may appear to be. Small defects neglected will finally destroy the efficiency of any engine. It takes but few small leaks to make a large one. Cornish engines invariably use a lantern brass to keep the piston rod stuffing box tight. A little steam is admitted to it, and the air is thus kept out. Such is their extreme care. Mr. Birkinbine, neglecting the leak of the piston, says that I am theoretically correct, but that practically it is unworthy consideration.

Theory says the expansion or leak in one case is ·1-inch. Mr. Birkinbine says that in practice it is not more than ·01, but he gives no authority; he simply guesses at it. Taking perfection, he adds

·9 to it for practice. Other engineers take ·9 from it, and are well satisfied.

The engines tested in the American Institute, of New York, were small, high-pressure engines, with, in all probability, a low grade of expansion, and with everything in favor of the unjacketed.

For the same powers developed, or combustible consumed, the radiating surface of the cylinders would be about one (1) of the high pressure to six (6) of the Cornish engine cylinder.

The rapidity of the alternations of pressure, and, therefore, of the temperatures, would make the mean difference of temperatures much less in the rotative than in the Cornish engine, and the condensation by radiation would consequently be less.

The difference of diameters of the ends of the cylinders must be considerable in the large and long cylinder, while it is very little in the small one. Indeed, the whole experiment referred to by Mr. Birkinbine is utterly worthless, as it stands, so far as large Cornish engines are concerned.

As Mr. Birkinbine insists upon throwing aside all experimental data obtained by our most celebrated physicists, and, with equal independence, determines to ignore the centuries' practice of the best practical mining and mechanical engineers that have ever given attention to the pumping of water, there is little profit to be obtained by discussing the steam jacket, if our object is to convince him only that it is a benefit.

I regret that Mr. Birkinbine is responsible for the West Philadelphia "twins" (the "Bulls"), and that I did not know he was referring to the Canal engine, but I am delighted to hear that they produced an average duty of over 600,000 foot-pounds for a whole month. When I saw them working there was evidently something wrong with the pumps. It appeared as if the passages from the well to the pump cylinders were too small, so much so that the water cylinders were only about half full when the equilibrium valves opened. The moving parts, with all the load, then dropped through half the stroke without meeting water, and of course were brought to with a violent shock. That is a strange way to reduce the supply of water, and I think one may be pardoned for regarding it with wonder. Other engines would run about half the speed to do half the work.

As Mr. Birkinbine went to London and saw for himself that the engines of that city averaged but a duty of 600,000 foot-pounds, we

are necessarily convinced that our Cornish engines are much better than the English; their famous Wicksteed engine doing about 27,000,000 less than the heretofore unheard of Easton engine. Mr. Henderson says, page 154, March, 1870, "The Cornish engines of this country, for a variety of reasons, are not equal to those in England."

How are these statements to be reconciled?

Unfortunately, for us, Mr. Henderson is right.

If, as Mr. Henderson says, there are engines running which give a lower duty than the Evans high-pressure engine, their owners will do well to present them to their enemies. They are not a credit to America, and are entirely new to me.

In regard to the interference of civil engineers with matters appertaining to another and entirely separate branch of engineering, I take the liberty of stating that the designers of all the best engines, of all kinds and descriptions ever produced, are, and have been, mechanical engineers. The best pumping engines ever built in England and America, the Fowey Consols and the Easton engine, were designed, built and erected by men who never did anything in the way of civil engineering, and who are content to spend their lives in mastering a single profession—mechanical engineering.

The "skilled mechanic" of the workshop has no more to do with making a machine than a strong laborer has to do with building a railroad, a bridge, or an aqueduct.

When the mechanic can, with profit, be put into the office of the mechanical engineer, the common miner may take the place of the geologist; the furnace man may occupy the chemist's laboratory; and the sexton may supersede the bishop. Many people attempt this thing, and the man who is so falsely and unfairly placed is only too glad to throw the blame of failure upon the American mechanic, when it is all caused by his ignorance of the true principles of design, and the desire of his employers to save a few hundreds, while they unconsciously lose thousands. So far is this misplacement carried, but still farther would Mr. Birkinbine take it by trying to force one man to learn two professions, while our leading engineers, civil and mechanical, are satisfied to do less than master one.

The "question" has led to a long discussion, which now narrows to the point at which we may ask who is right and who is wrong. If Mr. Henderson is right, his advice should be followed, but it must not be forgotten that his advice is, in effect, to build a Cornish en-

gine, good or bad, and it must beat every other of a different type, and equal any of its own type. If he is wrong, the proper course will present itself to our readers.

No one has questioned the correctness of any of the reasons given in my paper of October, 1868; they have but defended those given by Mr. Henderson.

Marine engineers invariably insure a certain effect; generally a certain speed for a certain amount of coal, of known quality, consumed, and a certain space occupied by machinery, boilors, etc. There is no such argument known as that *because* it is a *marine engine* the ship must go at a high speed. No Cornish engineer will say that because a Cornish engine is a Cornish engine, it will pump a great deal of water by the consumption of a comparatively small quantity of coal. Its correct design and construction do the superior duty.

Those advocating Mr. Henderson's views will be, and have been, of course, governed by those views in building engines. Individuals, companies and corporations requiring Cornish engines can procure them, at high prices, from the gentlemen so governed, but let them prepare to be astonished, for as long as they can be called Cornish engines, whether they are remarkably good or miserably bad, the reasons given by Mr. Henderson, and followed in construction, will prove them better than any other, and will also prove that all Cornish engines will do the same duty—this, in the face of the fact that one Cornish engine, built in America, does 94,000,000, while another does so little duty as to be unworthy of mention in the same breath with high pressure engines.

The owners of the Canal Cornish engine, having read Mr. Henderson's reasons, must feel rather perplexed at finding their engine proved to be a very excellent machine, after all the trouble they have had to keep it supplied with coal.

Cornish engineers have been experimenting and improving for scores of years; they have produced this 130,000,000 duty. More scientific men have been experimenting during the same time, and have come to the same conclusions. I but repeat what I have learned from them. I draw attention to the principles which they have established, and which govern the construction of machines in general, but which have been almost entirely neglected in the design of our Cornish engines. Singularity of appearance seems to have been the aim, and many a good shot has been made, but few good engines.

The causes to which I say the superiority of the Cornish engine is due are not purely theoretical, they come to us from this best practice. Keeping them before us we can make engines of correct proportion, and that is what the engineers of Cornwall learned to do by their long practice. All good engineers of our day base their calculations upon the results obtained from this and other experience, at the risk, it appears, of being called theoretical, yet they are successful.

If any of our readers feel sufficient interest in this discussion to take the papers written on the subject to some engineer who has built a real Cornish engine, doing good duty, say the builder of the Easton engine, at Bethlehem, Pa., question that gentleman, and compare his answers with the views we advocate, we shall know the truth, and shall have the satisfaction of seeing a change for the better wrought in the design and construction of the pumping engines of America.

This is not a simple or unimportant matter. It involves immense gains or losses. Where the Oliver Evans engine raises one pound a foot high, the Cornish engine raises more than six and a half pounds a foot high. The people of Philadelphia pay $6·50 for pumping water, while Cornish mining companies have paid as little as $1, if duties are reported correctly. If we doubt one, we must doubt all.

The people of West Philadelphia pay $1 for water, while the people of Easton pay but 70 cents, as shown by the duties reported by Mr. Henderson and Mr. Birkinbine.

Callao, Peru, July 25th, 1870.

SURVEY OF THE NICARAGUA ROUTE FOR A SHIP CANAL.

By Col. O. W. Childs, C. E.

(Continued from page 29.)

It will be seen by reference to the profiles of those portions of the river occupied by the canal, that the increase in the length of the cuts through the bars which a greater depth than that upon which the estimates are based would involve, consequently the ratio of increase of the expense of the canal, would be very great. Any considerable increase to the depth would require under-water excavations between the lake and the Toro Rapids, a distance of about 27 miles, to be almost continuous; it would very much

lengthen the cuts on other portions of the river, and the liability of these artificial channels to receive deposits of earth to such an extent as to obstruct the navigation, would be very much greater. On the inland portions of the canal a depth of 22 feet of water, which is about equal to the greatest draught of the largest merchant sailing vessels, would, with 50 feet bottom width, give a transverse water section about 45 per cent. greater than a depth of 17 feet with the same bottom width; and the expense of the inland portions would also, by reason of the greater depth of excavation, be increased in a still higher ratio.

The advances in improvements of model are such as are deemed sufficient to justify the belief that vessels of a burthen as great as before stated, may be so constructed as to navigate the canal. The steam ship Northern Light, recently built of the greatest strength, for general sea service, is of recent improved model, and excellent finish; the dimensions of this splendid steamer are such as would permit her to pass with full freight through the locks and the canal, and her burthen, as stated by the proprietor, is about 2,200 tons. It is not known that there are any steam ships plying between the Atlantic States and the eastern coast of the Pacific, that have a draught as great as 17 feet.

Of 261 steam vessels, principally English, the largest portion with side wheels, and the remainder screw propellers, as given in Murray's treatise on marine engines and steam vessels, only 15 draw over 17 feet of water, 21 have 17 feet draught, and 235 draw less than 17 feet, each at load line.

To construct the canal of dimensions capable of admitting the passage of vessels of the largest draught now in use, of which there are comparatively so few, or by which it would be so little used, and under circumstances of so much greater cost, while, as is believed, merchant vessels of equal tonnage and less draught may be so constructed as to be well adapted to sea service and the passage of the canal, would appear to be an injudicious application of means, which, as is supposed, your company would scarcely favor, or the intersest of commerce require. The dimensions before given were therefore planned and made the basis of the estimates with due consideration of the disparity in cost and general utility, of a canal of larger dimensions, and with a view to practicability as referable to cost of construction, usefulness, and a fair remuneration for capital invested.

This canal, as projected, is of much greater dimensions than any hitherto constructed in this country. If we except that of the Chesapeake and Delaware, which has 10 feet depth, the largest known on this side of the Atlantic, and most similar to that under consideration in respect to connecting natural with artificial navigation, are those in Canada East, by which the navigation is extended past the rapids on the St. Lawrence River, and the Welland canal in the Western Province, connecting the navigation of lakes Ontario and Erie.

The canals connecting the navigable portions of the St. Lawrence with each other are 7 in number, varying in length from ¾ to 11½ miles, with an aggregate length of 41 miles. They are 50 feet wide at bottom, and 90 feet at surface water line, excepting that at Beauharnois 11¼ miles in length, which is 80 feet at bottom, and 120 at top, and that at Cornwall 11½ miles long, having a bottom width of 100 feet, and a surface width of 150 feet. The locks are 27 in number, of which 20 are 200 feet in length between the gates, and 45 feet in width of chamber, and 7 on the Cornwall canal, have the same length and 55 feet width of chamber. All of the locks have 9 feet depth of water on the mitre sills, excepting 2 which have a depth of 16 feet.

The Welland canal is 28 miles long, 35 feet wide at bottom, and 71 feet at top, except a small portion, which is 45 feet in bottom width, and 81 feet at the surface.

The locks on the former portion, 24 in number, are 150 by 26½ feet, and on the latter portion, 3 in number; they are 200 by 45 feet in dimensions of chamber, all have nine feet of water on the sills. The whole fall from Lake Erie to tide water at Three Rivers on the St. Lawrence is 564½ feet, of which 536¾ is made by 54 lock, the remainder 27¾ by natural descent of the river. The aggregate length of the inland canal is 69 miles, and the whole distance from Lake Erie to Three Rivers is about 430 miles.

Sea-going vessels, carrying 350 tons, pass these canals. Although steamers and other sea-going vessels of much greater burthen pass on the St. Lawrence canals, yet owing to the want of a greater depth of water, they are understood to be limited to the above burthen. The extreme load of vessels adapted to the navigation of the Welland canal and the lakes is 400 tons of freight.

The Caledonian canal, forming a navigable connection for ships, between the east and west side of Great Britain, probably approaches in its dimensions and capacity, nearer to those proposed for the ship canal between the Atlantic and Pacific Oceans, than any other. This communication extends across the central portions of Scotland from Loch-Eil, connecting with sea on the westerly side to Loch-Beauly or Murrayfrith, an arm of the sea on the easterly side. It has a length of about 59 miles, of which 21½ is constructed inland, and 37½ is a navigation through the four lakes named in the order they occur, from West to East Lochy, Oich, Ness and Doughfour, originally of different elevations. The surfaces of Loch-Oich and Loch-Lochy now conform to the surface of the summit level of the canal; in construction, the former about 3¾ miles in length, was extensively dredged to obtain the requisite depth for navigation, and the surface of the latter about 9 miles in length, was raised 12 feet to lessen the depth of excavation through the summits between that lake and the western termination of the canal. Extensive dredgings were also made in carrying the canal through Lake Doughfour.

The canal is 50 feet wide at bottom, 110 feet at the surface water line, and 20 feet deep. It has 24 locks, with chambers 40 feet wide, and 172 feet in length. Its summit is 90 feet above the west, and 94 feet above the east sea, and the descent is made by 12 locks on either side.

Lake Ness has a length of about 20 miles, and together with the two lakes on the summit level are subject to changes of some 6 to 8 feet in their elevation by flood and drought. These flood waters are without difficulty retained for use or otherwise disposed of as the circumstances of navigation require.

This canal is similar then to that projected in Nicaragua, in its summit lake, from which in both directions it derives its supply of water, in the amount of its lockage, its dimensions, and in its frequent changes from inland canal to the adoption for purposes of navigation, of larger waters, and as also indicated from its history, (see *Encyclopædia Brittanica*,) the country, if we except climate, presented physical features, involving greater difficulties in its construction.

That canal was constructed previous to the introduction of steam as a motive power for sea-going vessels, and was designed for merchant vessels and vessels of war, of the dimensions of a 32-gun frigate.

The locks as designed for the Atlantic and Pacific Ship Canal, are large in their horizontal dimensions; they will admit of the passage of a large class of steamships, which, as a means of transit, from their annually increasing numbers, appear to be rapidly growing in favor.

The main advantages to be realized by the use of the Nicaragua canal is the saving of distance and time, in making a passage between the two oceans; these being primary causes of the extension of commerce, will in the present instance, produce benefits to be participated in by a large portion of the people of the globe. A knowledge, therefore, of this saving, to be effected by a passage through the ship canal, in making voyages between important commercial ports of the two continents, as well as between those on opposite sides of this, becomes interesting.

The following statement shows the distance between the several places named as measured on Mitchell's map of the world, Mercator's projection, and the difference in the distances between said places, by the way of Cape Horn and the proposed canal; also the time estimated to be required to make the voyages by steam and sail vessels, and the estimated difference between the two routes, in the time of making said voyages, admitting the steam to be uniform (except on the canal) throughout the several parts of the route, and to be for the steamer at the average rate of 280 miles, and for sail vessels 110 miles per day, and on the canal at rates the same as before stated.

Between what Places.	Name of Route.	Distance in miles.	Diff. of Dist. in miles.	Time occupied by steamers.		Time occupied by sail ves'ls	
				No days of voyage.	Diff. days of voyage.	No. days of voyage.	Diff. days of voyage.
New York and California.	Via Cape Horn.....	17,063		65½		155	
" " "	" Proposed Canal	5,690	11,373	23¼	42¼	53¾	101¼
" " and Valparaiso.	" Cape Horn.....	10,643		41		96¾	
" " "	" Proposed Canal	5,811	4,832	23½	17½	54¼	42½
" " and Sandwich Islands.	" Cape Horn.....	16,784		64¼		152½	
" " "	" Proposed Canal	7,173	9,611	28¾	35¾	66¾	85¾

The sailing distances, and the time occupied by sail vessels in making outward and homeward voyages, would, on account of prevailing winds and currents, be liable to differ widely from each other, and from those given in the above statement, which are intended to represent the time averaged for the outward and homeward voyages rather than the actual time of either. In the case of steamers, the difference would be much less, and the time estimated to be occupied by both steamers and sail vessels, averaged, as above stated, for the out and return voyage, is, upon the basis assumed, believed, nearly to be correct.

(To be continued.)

IRON MANUFACTURES IN GREAT BRITAIN.

THIRD PAPER.

By R. H. Thurston,
First Asst. Eng., Asst. Prof. Nat. Philos., U. S. N. A.; Member of the Institute.

Iron making is the most important branch of British manufactures. With the engineer it derives special interest, not only from this circumstance, but from the fact that, having been usually the first to adopt new methods and to originate new devices in iron making, we naturally expect to find in British practice much that is instructive, and look up to British makers as our tutors in the art.

In the year 1740, at which time smelting with coal had been

quite extensively introduced by Lord Dudley's successors, the production of cast iron from the 59 furnaces of Great Britain was reported at 17,350 tons. The rapid growth in production, during the hundred and thirty years that have since elapsed, to the present annual figure of 5,500,000 tons, is largely owing to the convenient proximity of the British ores to the coal beds which furnish the fuel with which they are smelted, and the source of the wealth and prosperity of the British Empire is readily found in the intelligence and industry with which such exceptional advantages have been improved.

One of the most extensive, and certainly the most prosperous and interesting of iron making localities in Great Britain, is the now celebrated Cleveland district in Yorkshire, along the valley of the Tees.

Twenty years ago this region was a barren moor, known in the neighboring counties as an excellent range for the sportsman, and *ten* years ago, Middlesborough, its river port, was a village of 7000 inhabitants, but the discovery of the ores of the Cleveland hills produced a wonderfully rapid change, and now about one hundred furnaces are in blast, and quite a number are in process of construction in this district. Middlesborough contains to-day 25,000 people.

The blast furnaces of the district are remarkable for their great size and their economy. Through the kindness of furnace proprietors and managers, we were enabled to examine the majority of furnaces situated near Middlesborough-on-Tees, and found much that was interesting and instructive in details of both construction and management.

The largest furnaces at this place are a pair, still unfinished, owned by Messrs. Cochrane & Co. They are 95 feet in height, 30 feet in diameter of bosh, and have a capacity of about 30,000 cubic feet. They will be fitted with the "Cowper-Siemens" hot blast stove, and, carrying a blast at a temperature of 1400° Fahr., or higher, are expected to produce about 900 tons of cast iron each, per week. These are exceptionally large for Middlesborough.

A pair of furnaces building by Messrs. Gjers, Mills & Co. are probably good representatives of the most approved Cleveland practice, in size and proportions. These furnaces are 85 feet high, and 25 feet in diameter of bosh, with hearths 8 feet in diameter and 8 feet high. They are built of Newcastle fire brick throughout, as are the adjacent buildings, its cost being comparatively low. The

stacks are hooped with iron bands and supported on brick pillars and buttresses; their foundations are of concrete, about six feet in depth, the materials being very carefully selected and mixed, and well compacted when in place.

The blast will be heated to about 1200° Fahr. by cast iron hot blast stoves; the fuel for heating the blast, and for making steam in abundance, is obtained by utilizing the furnace gases, a chimney 110 feet high giving the required draught. Four tuyeres are used in each furnace.

At works near the above described furnaces, we found a pair in blast, 85 feet high, 28 feet in diameter of bosh, driven with a blast at a temperature of 1000° Fahr., and at a pressure of 4 pounds per square inch, entering the furnace through four tuyeres, 5 inches in diameter: the product was stated at about 400 tons each per week, on an expenditure of 20 to 21 hundred weight of coke per ton of iron made. These furnaces were fully cased with sheet iron.

Another pair of furnaces, 80 feet high and 21½ feet in diameter, with blast at a pressure of 3¼ pounds and temperature of 1175° Fahr., were claimed to be running on 19 hundred weight of coke per ton of iron, while still other furnaces, of greater size, were expected to yield a ton of iron upon an expenditure of 18 hundred weight of fuel.

Still another pair of furnaces are 76 feet high and 23 feet in diameter of bosh. The blast, heated in Cowper stoves, enters the furnaces at a temperature of 1400° Fahr., through 5 tuyeres in each furnace, and at a pressure of 3¼ pounds. The product is stated at 1000 tons per week from the pair, their unusually large production being undoubtedly due to the high temperature of the blast.

The furnaces of the Ferry Hill Company, at some distance from Middlesborough, are said to be the highest in the district; they are 27½ feet in diameter and 103½ feet high. They were stated to be working with the blast at 1400° Fahr., and to be making 550 tons of iron each per week with 450 tons of coke. If this statement is correct, they are probably the most economical furnaces in the work, in the item of fuel.

The size and proportions of furnace that seemed most generally approved by Cleveland engineers was about 85 feet high and of a diameter of bosh equal to, or rather less than, one-third the altitude, with a hearth having a diameter of about one-eleventh the height. The larger number of furnaces in process of construction were of

about these dimensions, but some proprietors were indicating their conviction that much greater dimensions may be adopted with profit, by investing their capital in structures like those of Messrs. Cochrane & Co.

The gases from the furnace top are invariably taken off and thoroughly burned in the hot blast stoves and under the boilers. The "cup and cone" arrangement is always used at the furnace top, but there is a variety of devices for opening and closing in charging.

The hoists are of various kinds, the hydraulic, the steam and the pneumatic hoists all having their advocates. We examined them all carefully, and were very favorably impressed with all. The Howson steam hoist and with Mr. John Gjers' elevator; both worked with great smoothness, and it was a pleasure to ride on them.

The blast enters the furnace, generally, through either four or five tuyeres, at a temperature of 1100° to 1200°, where cast iron stoves are used. These stoves have either the Ω-shaped or the "pistol handle" pipes, both of which are found to stand well, although exposed generally to the direct action of the flame. Pleyer's hot blast stove was highly spoken of, but we were not so fortunate as to be able to visit the Norton furnace, where they were working.

Messrs. Cochrane & Co., and, we believe, other firms, use the *Cowper* hot blast stoves, in which the beautifully simple and economical principle of Siemens' "regenerator" is taken advantage of. The cast iron stoves, with a surface of about 1250 square feet per 1000 cubic feet of blast per minute, give a temperature of about 1100° Fahr., which is very near the working limit of temperature with cast iron, but the "regenerator" stoves carry the blast up to 1400°, and even, at times, to 1700° Fahr., a temperature which compels the use of water-jackets for the valve casings.

The first cost and expense of maintenance of these stoves are claimed to be no greater than with the ordinary cast iron stove, and Messrs. Cochrane & Co. testify to a very great economy from their use. The serious difficulties which, at first, arose from the collection, in the regenerator, of dust from the gases, have been gradually overcome, and the general introduction of this stove may probably be anticipated.

The Cleveland furnace of average size costs, complete, not far from £15,000.

The ores of the district are mined in the adjacent hills. Table 1 exhibits their chemical character. The ore is an impure argillaceous

ore, from the green lias, which loses about 25 per cent. by calcination. It is roasted in kilns, of a capacity of 200 to 300 tons, each, per week, which are ranged immediately behind the furnaces, and are kept continually at work; they consume about 1 hundred weight of fine coal for each ton of ore calcined. The roasted ore contains about 40 per cent. iron.

The coke used in the furnaces is exceedingly hard, and contains 92 to 95 per cent. carbon, with sometimes a considerable amount of sulphur. It is coked at the mines in ovens, the operation occupying 60 or 70 hours, and yielding 60 to 65 per cent. of the weight of coal charged. A large proportion of the fuel comes from the neighboring county of Durham.

The flux used is a limestone, which is obtained from several localities, not far distant. The finest qualities of Durham stone contain about 96 per cent. of carbonate of lime, but some managers prefer to use a cheaper limestone, which contains some 10 per cent. less of the carbonate of lime, and which also contains considerable magnesia.

The cinder from Cleveland furnaces contains so little iron as to lack, usually, the dark color which even a slight quantity of iron oxide generally gives. A fair specimen contained about 33 per cent. silica, 23 to 25 per cent. alumina, 30 to 35 per cent. lime, 2 per cent., or a trifle less, of sulphur, and ½ per cent. or less of oxide of iron; the remainder was principally magnesia.

The cinder is run from the furnace into little iron cars, in which it is wheeled away, and, usually, thrown into the river Tees, or dumped on its bank. Explosions, resulting from carelessly throwing the hot cinder into the water, have, in one or two cases, resulted fatally to the laborers employed in its removal.

The charge adopted here will not, generally, vary far from the following: ore, 8 hundred weight; limestone, 2½ hundred weight; coke, 3 hundred weight. The amount of coke is less in the largest furnaces.

The blowing engines at the furnaces near Middlesborough have vertical cylinders, with steam and air pistons on the same rod, and with crankshaft below. The Ferry Hill engine is probably the largest in the world, having a steam cylinder 67 inches in diameter, air cylinder of 130 inches diameter, with a stroke of 10½ feet. A pair of furnaces of 85 feet heighth and 26 feet diameter of bosh are supplied by three blowing engines, whose air cylinders are 84 inches

diameter, with stroke of 5 feet, making 25 revolutions per minute with a steam pressure of 40 pounds per square inch, and a pressure of blast of 3¼ pounds.

The remarkably low cost of iron made in Cleveland is evidently due to the great size of the furnaces, to the high temperature of blast, and to the skill exercised in obtaining a complete utilization of the furnace gases, and in general manipulation. The magnitude of the furnace has been increased until an approximation to the limit of crushing strength of materials charged has forbidden a nearer approach to the theoretical limit of economy. The temperature of blast has been raised until it has reached a point at which the greatest heat which can be obtained from the gases is reached, or in other cases, at which the material of the stoves begins to yield.

Mr. Bell and other engineers have investigated, with some success, the influence of size and temperature of blast upon economical production.

The benefit of enlarging the furnace is very marked at first, but becomes proportionally less and less as the capacity increases, until an increase from 25,000 cubic feet up to 30,000, the saving amounts to 3 or 4 per cent. of fuel, and between 30,000 and 35,000 cubic feet it becomes only about 2½ per cent., and so small an advantage is pretty nearly neutralized by the disadvantages and risks incident to such immense furnaces. Mr. Charles Cochrane states the maximum of economy to be obtained with a capacity of 50,000 cubic feet. With increasing temperature of blast, a similar decrease of gain is noticed, the economy in rising from 800° to 900° Fahr., being recorded as about 7 per cent, and between 1300° and 1400° Fahr., as 3½ per cent.

The tendency in Yorkshire is, however, toward still higher temperatures, and the "regenerator" stoves are obtaining favor as the only stoves that can carry such high heat without injury.

The Cleveland district is said to save more than 600,000 tons of coal per year by successfully utilizing the furnace gases in producing their high temperature of blast.

The market prices of Cleveland pig iron have been quoted for some time past at from about 52 shillings per ton for No. 1, to 46 shillings for No. 4, and even at these prices there is evidently a good margin for profit, if we may judge by the rapid increase of production, which is expected, during the current year, to reach 2,000,000 of tons.

The pig iron produced is not of fine quality. It is not at all suitable for steel making, but is a fair foundry iron, and when "fettled" with imported magnetite or pure hematite, has given a wrought iron of quite good quality—soft, but slightly cold short. Puddling is somewhat expensive, in consequence of the cost of ores imported to mix with native, and but little is done in the district. The cast iron is exported and puddled elsewhere, furnishing a large proportion of the "ship-plates" used in English iron ship yards, and finding a considerable market among rail makers.

An attempt has been made to work the "Siemens-Martin" steel process here, but it was found that the ore contained too much phosphorous to give a cast iron suitable for the purpose.

Cleveland practice in iron making exhibits most prominently the fact that, when engineers and furnace managers bring to their work a proper combination of scientific culture and practical skill, they may command success, even though laboring under the great disadvantages of impure ores and costly fuel. It is those two auxiliaries, rather than any natural advantages, that have placed the Cleveland district where it now stands among the iron making districts of Great Britain.*

Our space will not allow of as extended an account of other iron making localities of Great Britain, even had our limited time allowed as careful inspection as was made in the North Riding of Yorkshire.

(To be continued.)

* The details of construction and method in this model iron making district were studied with especial interest, with the intention of instituting a comparison with the facilities offered for the building up of a similarly prosperous business on the shore of Narragansett Bay.

The principal Rhode Island ores are a titaniferous magnetite, containing from 30 to 35 per cent. metallic iron and 10 per cent. titanic acid, and a hematite, which, when roasted, contains about 65 per cent. of iron. No sulphur or phosphorous are reported in the magnetite, and the hematite contains 0·2 per cent. of phosphorous and a trace of sulphur.

These ores are therefore much superior to the Cleveland ores, and the distance of transportation will be from six to ten miles for the ores and flux, and twenty-five for the fuel. Should the deposites prove as extensive as is anticipated, they can probably be more economically and profitably worked than any ore beds in the Eastern States. Iron, said to be of admirable quality, was made from these ores a century and a half ago, and the manufacture only ceased with the extinction of the forests which furnished the fuel. The subsequent discovery of a fair quality of anthracite, for smelting furnaces, has offered an opportunity for re-establishing the business.

AN EXAMINATION OF SOME EXPERIMENTAL FACTS BEARING UPON THE PROPER RATIO OF THE LENGTH AND BREADTH OF STEAMSHIPS.

By Alban C. Stimers, Naval Engineer.

The general success which has attended the adoption of the screw propellor in large ocean ships making long voyages is having the effect of not only driving paddle-wheel ships out of use but sailing vessels also. Now that our foreign commerce in American bottoms is almost extinct, owing to the unfavorable condition of our national affairs during the past few years, and our people are commencing to wake up to a consideration of the subject of re-establishing it, and again competing with the maritime nations of the world in the commerce of the ocean, it appears to me opportune to examine into some of the most important features of the steamship of the present with the hope of inducing a greater uniformity of practice than obtains abroad. It is with this view that I submit for publication the results of an examination of some experimental facts developed by the trials of British naval screw steamers in relation to the best proportion of the length to the breadth in that description of vessels, when constructed and employed for commercial purposes.

There is at present a great diversity of opinion and consequent practice regarding the most economic ratio of the length to the breadth of steamships, but the tendency is to greater and greater lengths as compared with the breadths.

One hundred years ago the celebrated De Chapman wrote in his *Architectura Navalis Mercatoria*, that in considering the proportions of large ocean ships generally, "that the breadth is between one-third and one-fourth the length." Fifty years later Knowles, author of a standard work on Naval Architecture, copied the exact words of De Chapman in remarking upon the same subject. These were, however, sailing vessels. When steam power was applied to the propulsion of ships, the proportionate length commenced to increase and has been increasing ever since, until now the ratio of seven to one is very moderate, and the limit of extreme comparative length to breadth is not reached within a ratio of between ten and eleven to one.

Whenever a British naval screw steamer is built, or when an old one is newly fitted with steam machinery, it is the practice of the Admiralty to cause her to undergo a trial of speed at a measured mile; and all the particulars of construction and of the phenomena attending the trial which are supposed to influence the speed or the economy of its attainment are noted in a table kept at the Admiralty office. This table was commenced about twenty years ago, and, on three different occasions, during that time it has been published, giving the particulars and results of the trials of all the screw steamers which had been completed and tried up to the respective dates of publication. It was last published in 1865, and the list then contained the names of two hundred and fifty screw steamers. Many of these were tried several times, and the table gives the particulars of each trial.

In addition to stating the facts of construction, management and observation, the table gives the results of calculations which exhibit the economic relations of steam power and speed as compared both with the immersed midship section, and the tonnage displacement. These results are regarded as co-efficients of performance, and are, of course, augmented by any improvement whatever in the form or proportions of the immersed hull, or in the screw propeller.

An examination of the table as published shows that the variety of the combination of different forms and proportions of hulls and propellers is nearly as great as the number of vessels. Although this fact has the appearance of a barrier to a proper comparison of the excellence of one particular proportion of the hull with another, when the whole number of vessels is divided into classes having the proportion under examination properly assorted into each class, it is found that all the other items of varying proportions are pretty equally distributed through the various classes, and that therefore the mean of the coefficients of performance of each class will give a pretty fair indication of the economic excellence of the proportion thus examined.

It is upon this principle that I have proceeded to ascertain the influence of the varying proportions of the length and breadth of the vessels tried. The variation in the ratios extend from 3·33 to 7·87 breadths to 1 length, and I have divided them into five classes, as follows:—

Class A having ratios of less than $3\frac{1}{2}$ to 1 in which there are ..... 12 vessels.
" B having ratios of more than $3\frac{1}{2}$ and less than $4\frac{1}{2}$ to 1 in which there are ..... 65 "
" C having ratios of more than $4\frac{1}{2}$ and less than $5\frac{1}{2}$ to 1 in which there are ..... 78 "
" D having ratios of more than $5\frac{1}{2}$ and less than $6\frac{1}{2}$ to 1 in which there are ..... 68 "
" E having ratios of more than $6\frac{1}{2}$ to 1 in which there are ..... 27 "

The coefficient employed for comparison is that which relates to the tonnage displacement, because, although the one relating to the midship section is technically useful to professional men in considering some of the detail questions of steam navigation, it does not apply to the economy of transporting a given amount of cargo across the sea, while the other does.

Although the speed at the time of the trial does not enter directly into the question, any variation in that regard being provided for in the formula which produces the coefficient, it is interesting to state it.

In the following tables, therefore, will be found the name of each vessel, the ratio of length to breadth, the speed at the time of trial, and the coefficient derived from the formula—

$$\frac{V^3 \times D^{\frac{2}{3}}}{H.P.} = C;$$

where V = velocity in knots per hour.
D = displacement of the vessel in tons.
HP = indicated horse-power; and
C = coefficient of performance.

The speed given is not always the maximum, but is that which was attained at the trial which achieved the maximum coefficient, and the coefficient given is always the maximum one where the vessel was tried more than once.

Class A having Ratios of Less than $3\frac{1}{2}$ to 1.

Names of Vessels.	Ratios of L to B.	Speed knots.	$\frac{V^3 \times D^{\frac{2}{3}}}{H.P.} =$	Names of Vessels.	Ratios of L to B.	Speed knots.	$\frac{V^3 \times D^{\frac{2}{3}}}{H.P.} =$
Aboukir	3·40	9·550	122·1	*Exmouth	3·40	9·100	159·1
*Albion	3·39	10·968	147·4	Goliath	3·35	9·160	101·6
Brunswick..	3·41	7·742	76·3	*Irresistible.....	3·35	11·010	161·0
Centurian	3·33	8·550	108·0	*Lion	3·37	9·529	196·2
*Collingwood.....	3·37	10·460	150·9	Majestic.....	3·35	8·783	118·3
Colossus	3·33	9·660	134·9	*Windsor Castle.	3·40	10·955	140·4
		Means of above 12 vessels.....			3·37	9·620	134·9

Class B having Ratios of more than $3\frac{1}{2}$ and less than $4\frac{1}{2}$ to 1.

Names of Vessels.	Ratios of L to B.	Speed knots.	$\frac{V^3 \times D^2}{H P}$	Names of Vessels.	Ratio of L to B.	Speed knots.	$\frac{V^3 \times D^2}{H P}$
Ajax	3·62	7·147	91·5	*Imperieuse	4·24	10·673	191·7
*Algiers	3·65	9·030	183·9	*James Watt	4·15	9·500	168·6
*Agamemnon	4·16	11·243	185·2	*London	3·96	9·508	208·6
Amphion	4·10	6·750	83·1	*Marlborough	4·01	11·866	170·0
Anson	4·42	12·984	158·7	*Narcissus	4·45	10·946	174·3
*Arrogant	4·37	8·295	166·1	*Nelson	3·97	10·363	201·2
Atlas	4·42	13·022	147·6	*Neptune	3·91	10·897	178·4
Blenheim	3·73	5·816	41·5	Nile	3·79	8·200	120·1
*Bombay	4·47	10·157	164·3	*Orion	4·27	11·466	190·1
*Cæsar	3·70	10·274	167·6	Pembroke	3·63	7·602	140·1
*Chesapeake	4·24	9·658	173·4	Phaeton	4·42	10·466	146·8
Conqueror	4·34	10·806	142·6	*Princiss Royal	3·73	11.031	203·5
Cornwallis	3·61	7·188	91·0	Queen	3·57	10·578	129·1
Cressey	3·61	7·206	83·3	*Renown	4·42	11·430	165·4
*Curacoa	4·46	8·668	197·3	Revenge	4·42	11·530	158·6
*Donegal	4.33	11·912	173·6	Rodney	3·97	11·479	144·0
*Duncan	4·34	13·322	187·6	*Royal Albert	3·82	10·000	174·5
Duke Wellington	4·01	9·891	156·5	Royal George	3·77	9·568	138·0
*Edgar	4·16	11·371	164·7	*Royal Sovereign	4·01	12·253	166·4
Edinburgh	3·63	8·873	137·2	Royal William	3·90	10·581	155·5
Eurotus	4·07	7·579	92·0	Russell	3·65	6·680	104·9
*Emyalus	4·23	10·038	171·3	St. George	3·98	10·933	200·1
*Forte	4·16	11·485	175·0	*St. Jean D'Acre	4·30	11·199	200·9
Forth	3·77	9·384	146·3	Sans Pareil	3·83	9·300	133·2
Fox	3·96	9·218	141·8	Sea Horse	3·80	9·298	142·8
Fred'k William	3·57	11·777	157·2	Trafalgar	3·89	10·908	140·1
Gibraltar	4·34	12·480	142·5	*Tribune	4·47	9·551	202·2
Hannibal	3·74	8·600	131·6	*Victor Emanuel	4·16	12·009	190·9
Hastings	3·65	6·702	98·4	*Victoria	4·33	9·700	165·6
Hero	4·23	11·350	155·5	*Waterloo	3·94	11·329	175·3
Hague	3·80	8·328	153·4	*Zealous	4·30	10·246	177·9
Hood	4·27	11·752	156·0	Horatio	3·83	8·855	139·8
*Howe	4·26	11·161	180·2				
Means of above 65 vessels					4·03	10.051	155·2

Class C having Ratios of more than 4½ and less than 5½ to 1.

Names of Vessels.	Ratios of L to B.	Speed knots.	$\frac{V^3 \times D^2}{H.P.}$ =	Names of Vessels.	Ratios of L to B.	Speed knots.	$\frac{V^3 \times D^2}{H.P.}$
*Alert	5·01	9·607	183·5	*Megaera	5·47	9·958	183·6
Ariel	4 98	7·647	148·2	Melpomene	4·56	12·436	173·5
Aurora	4·53	11·335	158 0	Mutine	5·20	10·250	154·6
Bachante	4·70	12·049	167 9	*New Castle	4 81	13·287	183·3
Bristol	4·81	10·079	159·2	*Ocean	4·67	12·896	191·5
Cadmus	4·96	11·825	173·6	Octavia	4·78	9·897	176·5
*Caledonia	4·61	10·713	189·4	Pantaloon	5·19	8·934	126·8
Challenger	4·96	10·601	159·8	*Pearl	4·96	10·988	202·2
Charybdis	4·96	11·752	138·8	*Pelorus	4·96	9·045	177·8
Clio	4·96	9·805	171·3	Peterel	5·28	8·927	153·7
Columbine	5·27	8·742	170·3	*Phœbe	4·67	9·959	226·8
*Constance	4·79	10·575	198·5	Phœnix	5·48	8·740	149·0
Cordelia	5·19	9·912	148 8	*Plumper	5·09	7·228	183·7
Cossack	5·06	8·655	139·1	*Prince Consort	4·67	10·330	219·2
*Cruiser	5·01	6·608	220·2	*Pylades	5·02	8·044	203·7
Dauntless	5·28	10·293	156·5	Racer	5·19	7·325	158·7
*Defence	5·17	11·618	203 5	*Racoon	4·96	9·958	199·1
Defiance	4·60	8·960	118·8	Rapid	5·27	7 286	137·0
Diadem	5 09	11·661	163·8	*Rattler	5·39	10·074	217·7
Doris	5·00	11·981	145·6	*Research	5·06	8·220	185·4
Emerald	4·51	11·726	175·1	*Resistance	5·18	10·372	245·7
Enterprise	4·99	8·037	175·3	*Reynard	5·30	8·238	207·5
*Echo	5·30	8·064	211·9	Rosaris	5·27	9·236	158·5
*Falcon	5 03	8·653	189·7	Royalist	5·27	9·818	170·8
*Faron	5 03	7·238	179·8	*Royal Oak	4·67	11·127	216·4
Gannet	5·19	8·445	160·5	*Satellite	4·96	9·366	194·7
*Glasgow	4·80	13·102	187·4	Secret	4·96	10·568	147·2
Greyhound	5·19	9·052	149·8	*Scylla	4·95	9·092	184·7
Harrier	5·03	8·320	165·0	*Severn	4 81	11·695	177·5
*Hector	4·97	10·243	208·2	*Shannon	4·70	11·708	182·9
*Highflyer	5 28	9·416	177·8	Shearmater	5·23	8·957	124·5
*Hornet	5 02	7·750	197·0	*Sutley	4·93	13·067	188·9
Icarus	5·19	10·146	125·7	Swallow	4·98	7·429	147·4
*Immortalite	4·82	10·940	231·0	Tartar	5·06	9·400	138·8
*Jason	5·45	11·632	176·7	Termagant	5·19	10 660	141·4
*Leander	4 74	10·276	185·3	Topaze	4·70	12·160	175·5
*Liffey	4·70	9·072	212·5	*Undaunted	4·80	10·972	193·5
*Liverpool	4·69	10·620	210·1	Valiant	4·97	11·433	144·4
Lyra	4·99	7·458	142·2	*Vulcan	5·31	9·511	185 8
Means of the above 78 vessels					5 00	9·913	175·5

Class D having Ratios of more than $5\frac{1}{2}$ and less than $6\frac{1}{2}$ to 1.

Names of Vessels.	Ratio of L to B.	Speed knots.	$\frac{V^3 \times D^{\frac{2}{3}}}{H.P.}$	Names of Vessels.	Ratio of L to B.	Speed knots.	$\frac{V^3 \times D^{\frac{2}{3}}}{H.P.}$
Alacrity	6·35	10·870	148·2	Orestes	5·53	12·265	174·1
Archer	5·51	7·520	166·0	*Orlando	5·77	13·001	187·4
*Ariadne	5·60	12·680	183·2	*Orpheus	5·53	9·207	193·6
Arrow	6·32	11·000	156·9	Osprey	6·33	7·500	159·4
Assurance	6·35	9·233	176·5	*Pandora	5·71	10·482	199·0
Barrosa	5·53	10·086	166·9	*Pelican	5·57	11·666	198·0
*Beagle	6·32	9·409	183·3	*Penguin	5·72	11·078	205·8
*Brisk	5·53	9·309	210·3	Perseus	5·56	10·148	170·2
*Cameleon	5·58	10·206	198·4	*Philomel	5·72	10·850	212·4
*Chanticleer	5·58	11·258	188 8	*Plover	5·72	10·587	184·5
*Conflict	5·61	9·772	178·0	Ranger	5·72	9·006	172·9
Coquette	6·35	7·768	173·0	Rattler	5·58	7·692	170·0
*Cygnet	5·71	8·667	215·5	*Rattlesnake	5·53	12·238	207·9
Dart	5·72	8·708	159·7	*Rifleman	5·64	7·977	182·6
*Desperate	5·60	8·875	224·2	*Rinaldo	5·58	11·781	206·0
*Encounter	5·72	10·669	186·7	Ringdove	6·35	10·824	149·7
*Espoir	5·72	9·017	180·2	Sharpshooter	5·65	9·327	175·5
*Foxhound	6·35	11·600	185·4	*Simoom	6·00	8·747	240·5
*Galetea	5·58	10·538	216 0	Snake	6·32	10·303	146·2
*Greenock	5·69	9·630	191·4	Snipe	5·72	10·320	162·8
Griffon	5·72	10·119	177·2	*Sparrow	5·72	10·872	177·5
Jaseur	5·72	9·596	150·7	*Sparrowhawk	6·35	9·070	178·1
*Landrail	5 72	6 870	185·1	Speedwell	5·71	6·712	176·3
Lapwing	6·35	11·021	164·7	*Steady	5·72	11·053	205·8
*Lee	5 69	9·691	178·4	Surprise	6·35	11·149	153·3
Lynx	6·32	7·033	109·7	Teaser	5·96	7·682	123·1
*Malacca	5·59	9·094	218·0	Torch	5·72	10·032	174·1
Mersey	5·77	13·290	176·6	Vigilant	6·35	8·447	168·7
Minx	5·93	5·441	121·8	Viper	6·32	11·860	176·4
*Miranda	5·77	10·759	247·5	Wanderer	6·35	10·733	143.8
Mohawk	6 35	9 925	173·5	*Wasp	5·51	8·176	214·2
Mullet	5·70	10·067	156·1	*Wolverine	5·52	11·256	193·2
*Niger	5·61	9·705	179·7	Wrangler	6·32	8·012	153·1
Nimble	5·72	9·933	159·6	Zebra	5·58	9·874	142·7
Means of the above 68 vessels					5·84	9·842	178·9

Class E having Ratios of more than 6½ to 1.

Names of Vessels.	Ratios of L to B.	Speed knots.	$\frac{V^3 \times D^{\frac{2}{3}}}{H.P.}$	Names of Vessels.	Ratios of L to B.	Speed knots.	$\frac{V^3 \times D^{\frac{2}{3}}}{H.P.}$
*Achilles	6·52	11·879	261·1	Nimrod	6·63	8·818	175·3
*Adventure	7·77	10·316	237·8	*Orontes	6·72	10·880	253·9
*Assistance	7·77	10·663	237·6	*Pereverance	7·08	11·297	275·4
*Black Prince	6·55	12·221	235·8	Pioneer	6·59	11·366	127·7
Connorant	6·53	11·155	154·0	Race Horse	6·53	10·937	143·4
Dwarf	7·87	10·537	115·1	Roebuck	6·63	9·447	165·2
Eclipse	6·53	9·274	145·0	Serpent	6·53	9·724	118·3
*Fairy	6·85	13·229	198·1	Star	6·53	11·100	115·8
Flying Fish	6·59	9·923	177·5	*Supply	6·62	9·079	235·8
Flying Fish	7·19	10·409	191·7	Tamar	6·73	9·641	186·1
*Himalaya	7·38	12·900	297·4	*Transit	7·23	11·909	260·6
*Industry	6·62	8·400	246·6	*Urgent	7·11	11·996	252·0
Intreped	6·63	10·250	118·9	*Warrior	6·55	11·040	289·6
Lily	6·53	10·000	155·7				
Means of the above 27 vessels					6·86	10·681	198·9

Recapitulation of Mean Results.

Class	Number of Vessels.	Ratios of Length to Breadth.	Speed in Knots per hour.	$\frac{V^3 \times D}{H.P.}$
A	12	3·37 to 1	9·620	134·9
B	65	4·03 to 1	10·051	155·2
C	78	5·00 to 1	9·913	175·7
D	68	5·84 to 1	9·842	178·9
E	27	6·86 to 1	10·681	198·9

From the foregoing classification, it is clearly demonstrated, in the most practical manner, that, within the limits of the proportions tried in the British Navy, the greater the ratio of length to breadth the more economically will a given displacement be driven at a given speed through the water; and if this was the whole problem it would not be necessary to pursue the subject farther. It is, however, only a part of it. The question requiring to be answered is, What is the proportion of length to breadth which will pay the highest dividends upon the capital invested?

BELTING FACTS AND FIGURES.

By J. H. Cooper.

(Continued from page 187.)

Belts.

"The driving pulleys fixed upon the shaft should be well centered, so that there may be no inequality of motion which would destroy the belts,

"To transmit motion to the apparatus without noise or loss of power, tanned leather belts of first quality are preferably used. They wear one and a half times as long as those of inferior qualities, which, although their low price is an inducement to purchasers, are more expensive in the end, by the stretching and rapid deterioration they undergo.

"The greater or less thickness of belts often contributes to their stretching and the continual variations to which they are subject while extended over the circumference of pulleys or drums.

"For high powers, well tanned leather of sufficient thickness should be preferred. I have prepared the following table, which gives the thicknesses of belts calculated from the variable power of machinery, and the diameters of pulleys:

No. of Horse-power.	Thickness in millimetres. Pulley diam. at least = 0m·30.	Thickness in millimetres. Pulley diam. at least = 0m·20.
½	5½	5
1	6	5½
2	6½	6
3	7	6½
4	7½	7
5	8	7½
6	8½	8
7	9	8½
8	9½ doubled belt.	9 doubled belt.
9	10 " "	9½ " "
10	11 " "	10 " "

"It is rare that a force of over 10 horse-power is transmitted by means of belts.

"For a force of 8 or 10 horse-power, the belts should be double, which prevents their stretching; that is to say, two belts are super-

posed and sewed together at their edges. Thus, for a 9 horse-power two belts are sewed together, one of which is 1 millimetre thicker than the other: 5·5 below and 4·5 above, making 10 millimetres, the thickness of a belt which will resist the action of this power and even a greater one. For low powers, the thickness is always from 4 to 5 millimetres.

Table for Ascertaining the Width of Belts.

Velocity per minute in Metres.	Width of Tanned Leather Belts in Millimetres. Force in Horse-Power						
	$\frac{1}{10}$	$\frac{2}{10}$	$\frac{5}{10}$	$\frac{9}{10}$	1	2	3
20	68	132	328	.....	.....	.....	.....
30	44	88	220	394	.....	.....	.....
40	34	66	164	296	.....	.....	.....
50	26	53	132	237	.....	.....	.....
60	22	44	110	197	220	440	.....
70	19	38	94	170	188	377	565
80	17	33	82	148	165	329	494
90	15	29	73	132	147	293	440
100	13	26	66	119	132	264	396
120	11	22	55	99	120	220	330
140	9	19	47	85	94	188	283
160	8	17	41	74	82	165	247
180	.....	15	37	66	73	147	220
200	.....	13	33	55	66	132	198
240	.....	11	28	47	55	110	165
280	.....	9	24	41	47	94	141
300	.....	8	22	39	44	88	132
360	.....	.....	18	33	37	73	110
400	.....	.....	16	28	33	66	99
500	.....	.....	13	24	26	53	79
600	.....	.....	.....	.....	22	44	66
700	.....	.....	.....	.....	.....	38	56
800	.....	.....	.....	.....	.....	.....	50
900	.....	.....	.....	.....	.....	.....	44
1,000	.....	.....	.....	.....	.....	.....	40
1,200	.....	.....	.....	.....	.....	.....	33
1,500	.....	.....	.....	.....	.....	.....	26
2,000	.....	.....	.....	.....	.....	.....	20

"The transmission of motion from one shaft to another, by means of belts, depends entrely upon the friction produced by their tension upon the pulleys or drums around which they are made to move. If the force transmitted by them is augmented, the friction is in like manner increased; and if in that case the tension of the belts remains the same, their friction surface, or, what amounts to

the same, their breadth must be increased:—*the powers to be transmitted are to each other as the product of the width of the belts multiplied by the velocity.*

"M. Morin has found that belts of tanned leather will resist a tension computed at two kilogrammes for every square millimetre of their section.

"When it is desired to determine the width of a certain belt, *multiply the number of revolutions of the pulley or drum, made in one minute, by its circumference and the product will express in metres the desired velocity.* The width in millimetres will then be found opposite this number, and in the column of the foregoing table of the given power. If pulleys, however, are not in the relation of identical diameters, but are in the relations about to be mentioned, *then multiply the width given in the foregoing table by the coefficient of transformation.*

"*Coefficient of Transformation of the width of belts according to the relations of the diameters of pulleys.*

"For pulleys, the diameters of which are to each other as 1 : 2, the width indicated in the table will be multiplied by 0·75. For the ratio of 1 : 3, the multiplier will be 0·65; and for the ratio of 1 : 4, 0·58."

Experience shows that belts ought never to be less than 20 millimetres wide, as they are subject to stretching and breakage. Their width should also exceed that ascertained from the table by at least one-sixth. Machines working different materials, with varying quantities, undergo more or less strain. Thus, a spinning mule, after having worked ten hours, absorbs one-fifth more power than at the outset. Wet weather occasions the same effect, while obstructions, want of oiling, materials more or less difficult to spin, &c., are so many causes which have to be neutralized by developing the friction surfaces of the belts.

Loss of Velocity suffered by Belts while in Motion.

"The variable length of the belts has an influence upon their slipping: when they are crossed they are less liable to slip.

"The loss of velocity suffered by belts, when mounted, depends upon their friction surface.

"Long belts are less liable to slip than short ones, for the latter are always stretched in a manner injurious to the journals and

brasses, and notwithstanding this amount of tension, they are still subject to a considerable loss in velocity.

"I have undertaken some experiments in regard to losses of this nature, to which belts are liable, relatively to their lengths, and I have thought it well to prepare a table, for calculating the amount of motion transmitted by belts which no operator can well do without.

Table showing the Slip of Leather Belts relatively to their Lengths.

Parallel belts. Length in metres.	Percentage of velocity lost by slipping.	Crossed belts. Length in metres.	Percentage of velocity lost by slipping.
2	4·2	2	3·5
4	3·9	4	3·2
6	3·6	6	2·9
8	3·3	8	2·6
10	3·0	10	2·3
12	2·7	12	2·0
14	2·5	14	1·8
16	2·3	16	1·6
18	2·1	18	1·4
20	1·9	20	1·2

"Belts, after having served for a certain length of time, and having withstood more or less tension, become greatly impaired by stretching and narrowing.

"The width of belts diminishes in proportion to the strain upon them. Experience shows that on the first day a belt is used it suffers an elongation of one per cent. This action continues to diminish till the third day, after which the belt works on without much change in its dimensions.

"The causes producing loss of velocity in belts are imperfect lubrication of machinery, obstructions in the journal boxes, wheel gearing out of line, inferior quality of leather, couplings and sewing, and oil on the pulleys.

"When a belt slips, the difficulty is remedied by sprinkling the rubbing surface with a mixture of Spanish white and resin. If the belt is smeared with oil, Fuller's earth is employed, which has the property of absorbing greasy substances, and the rubbing side of the belt is then scraped with a wooden blade.

"Very often a badly made knot in a coupling joint will cause the belt to lose one or two per cent. of velocity.

"To transmit and secure the motion to be imparted, the belts are sewed in such a manner as best to insure against their slipping; but as they always tend to elongate, in order to obviate this difficulty, the ends are bound together by a leather thong. These are generally of Hungarian leather, cut into thin and narrow strips, so as to be readily handled, as well as to avoid the necessity of punching large holes in the belt, which greatly lessens its strength.

"The flaxen or hempen thread, intended for sewing belts, ought to be of superior quality, and smeared with some pitchy substance to prevent ravelling.

"M. Hunebelle, of Amiens, manufactures very durable belts, the couplings of which are made of Hungarian leather prepared in some peculiar manner. I have substituted animal substances for thread. I have had good results from eel-skins, and have also tried small cat-gut. My experience has been that the belt of a spinning frame, sewed with this material, may last two years without suffering any deterioration; and the cost of this article is not so great as to oblige us to reject its employment.

"Pulleys should have a rise of one-twelfth of their face width.

"Sometimes, to impart motion to a machine situated at a distance from the transmission, we resort to what is called a binder or carrying pulley which consists of two small wooden drums, having a face convexity of one-twentieth their width, secured to iron axles running in brasses, the whole made adjustable. These drums should never be less than 20 centimetres ($0^{m}{\cdot}20$) in diameter, a large diameter never does harm. This contrivance, which was first introduced by a foreman named Buignet, stretches the belt in every direction."—*A Practical Treatise on the Manufacture of Worsteds and Yarns.* M. Leroux. H. C. Baird, Phila., 1869.

(To be continued.)

An Instructible Metallic Packing as applied by Mr. Girdwood, London, is described in the *Mechanics' Magazine.* Copper wire is closely woven into sheets and then rolled up to a proper thickness; it is now pressed in a square or other shape and bent into a ring, the two ends being brought close together by means of a press, so as almost to unite them. These flexible and seamless rings readily admit of the proper pressure to obtain a perfect joint by the cover screws, and being of metal and unalterable by heat can be used with great advantage for high pressure and superheated steam.

Mechanics, Physics, and Chemistry.

THE GRAPHICAL METHOD.

By Prof. Edward C. Pickering.

One of the most valuable means of studying physical laws is the graphical method, or the representation of phenomena by curves. If any two quantities are so connected that an alteration of one produces a change in the other, a curve may be constructed in which ordinates and abscissas correspond to the magnitudes of these variables. The principal objection to this method is its inaccuracy, and the object of the present article is to show how this difficulty may be avoided, and the errors reduced to any desired magnitude. One of the most accurate applications of the graphical method was that of Regnault, in his study of the laws of heat. He used a copper plate, ·8 of a metre square, and constructed points by means of a miniature dividing engine, giving hundredths of a millimetre, or five places of decimals. Probably, however, the last of these would be very doubtful, and in the printed sheet even the fourth figure is liable to an error of one or two units. Again, it is difficult to draw a curve through a series of points, unless they fall near together, and therefore, in practice, we can hardly depend on more than three places of figures with certainty. That is, if all our points fall between 0 and 1, our errors should not exceed one-thousandth, if between 0 and 100, one-tenth.

The most obvious means of diminishing errors is to enlarge the scale. This is, however, limited by the size of the paper, and has moreover the disadvantage of making the points fall further apart, and thus rendering it more difficult to draw a smooth curve through them. In many cases, therefore, a large curve is no better than a small one. This objection does not apply to the straight line and circle, since they may be constructed by the ruler and compasses, but it then becomes necessary to construct all the points to a scale, as a distortion is almost always introduced in paper ruled or engraved in squares, by its unequal expansion by moisture. The next question is the degree of accuracy as affected by the inclination of the curve to either axis. Generally, after constructing our curve, we

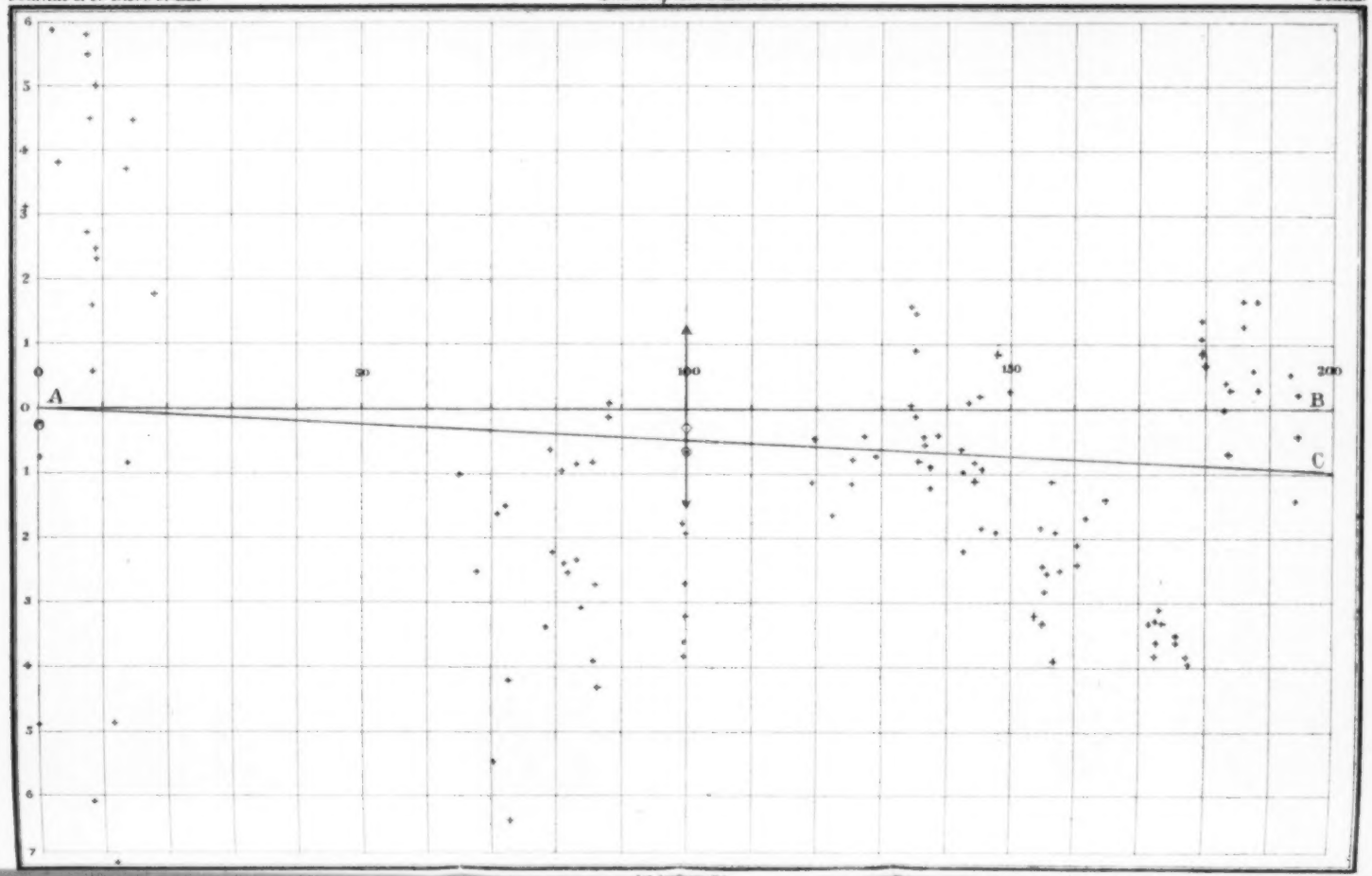
wish to know the magnitude of one variable corresponding to certain values of the other, that is, we draw horizontal lines corresponding to certain assumed values of y, and the abscissas of the points where they meet the curve will give the corresponding values of x. If the curve is nearly horizontal, large errors may be introduced, owing to the obliquity of the intersection, and if nearly vertical, there is the same trouble with the values of y. Now, it is by no means necessary that abscissas and ordinates should be taken to the same scale; in fact, they usually represent different units. By increasing the scale on which abscissas are constructed, we render the curve more nearly horizontal, increasing the scale of ordinates, more nearly vertical. The question then arises with what degree of accuracy can these intersections be found at different inclinations, and what scales must be adopted to give the best results. Evidently, the error will be proportional to the space through which the lines coincide, or to their thickness divided by the sine of their angle of intersection. Calling, therefore, α the angle the curve makes with the axis of X, the error in determining $x = \frac{e}{\sin.\ \alpha}$, and for $y = \frac{e}{\cos.\ \alpha}$, e being the error when the lines are as right angles, or its minimum value. When $\alpha = 45°$, the two last errors $= 1{\cdot}4\,e$, the most favorable case. When $\alpha = 30°$, the error of x or $e_x = 2\,e$ „ $e_y = 1{\cdot}12\ e$; $\alpha = 90°$, gives $e_x = 0$; but $e_y = \infty$, or the point of intersection cannot be obtained since the two lines coincide. One conclusion then is that the scale must be taken such that the curve will not be very oblique to either axis, the best effect being attained with angles of 45°. When the scale is enlarged in one direction only, the accuracy is not proportional to the enlargement, but depends on the direction of the curve. As the direction of a curve is commonly given by the tangent of the angle it makes with the axis of X, let tang. $\alpha = \frac{a}{b}$: then $e_x = \frac{\sqrt{a^2 + b^2}}{b} e$; $e_y = \frac{\sqrt{a^2 + b^2}}{a} e$. If we enlarge the scale of x, m times that of y, n times, we have $e_x = \frac{\sqrt{a^2\,m^2 + b^2\,n^2}}{b\,m} e$.

$e_y = \frac{\sqrt{a^2\,m^2 + b^2\,n}}{a\,n} e$, from which we can readily compute the increased accuracy due to the enlargement in any case.

Let us now suppose that we have a sheet of paper 1 metre square

divided into millimetres, and that on this we have constructed a curve to such a scale that it extends nearly diagonally across the sheet, and that all our observed points agree with theory within a millimetre. It will generally be only difficult to decide whether these errors, although occurring in the fourth place of decimals are real variations from theory or only accidental errors. Moreover, only a very small part of the paper is used, the ruling on ninety-nine hundredths of it being quite useless. We then construct a curve in which while x is unchanged, y represents the deviation between the observed and theoretical curve the scale being enlarged 10 or 100 times. Evidently the errors will now become so large that we can tell at a glance whether they are accidental or constant, and if the latter, how the curve must be altered to diminish them, or by what amount we must correct any point of our theoretical curve to make it agree with observation.

This method has special value in obtaining empirical formulas from series of observations. We assume some simple equation as a first approximation, and construct points as before, giving differences on an enlarged scale. Treat this new curve precisely like the first one, assuming a second approximate equation, and so proceed until all deviations except those of observation are eliminated. Placing y equal to the sum of all these assumed values, (first reducing them all to the same scale) we have the required empirical equation. To put the matter in a mathematical form, let x'' and y'' be co-ordinates of each observed point in succession. Assume the curve $y = f(n)$ which shall nearly coincide with them and construct the points whose coordinates are x'' and $[y'' - f(x'')]\ 10$. As an approximation to this last curve take the formula $y = f'(x)$, and construct again a curve with co-ordinates x'', and $\Big([y'' - f(x'')]\ 10 - f'(x'') \Big)\ 10$. Having finally destroyed the constant errors we have the required equation $y = f(x) + \frac{f'(x)}{10} +$ &c. It is best where practicable to assume some simple value of $f(x)$, $f'(x)$, as $a\,x + b$ or $a \log x + b$ making $a = 1, 2, 3, \cdot 5$, &c. Much labor is thus saved and we can often find a simple equation which will satisfy observation as well as any complex one. The examples given below explain this method more perfectly than any description, and show how easy it is to compare different empirical formulas.


A
B
C
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20
100
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200
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5
6
7

A point of inflexion is readily found by assuming equations of the form $f(x) = a\,x + b$, and making these lines approximately tangent to the curve at the required point. Maximum and minimum values of y are found by drawing the axis of X very near these points and enlarging y.

Asymptotes present especial difficulties to the graphical method as commonly used. Suppose we have a curve asymptotic to the axis of X. Construct a curve in which while y is unchanged x shall be the reciprocal of that previously taken. Then all points of the curve between 1 and ∞ will now be included between 1 and 0. It is often desirable to determine the area included between the curve and asymptote. If this is finite our new curve will be tangent to the axis of x at the origin. Its magnitude may be determined by constructing a third curve in which x is, as before, the reciprocal of its first value, while y for any point is proportional to the area included between its ordinate and that of some other point assumed as an origin. These values of y may be obtained from the original curve by the usual processes of measurement. The ordinate of the point where our new curve meets the axis of y gives the total area required. As an application of this device, see an article by the writer in this *Journal*, March, 1870, entitled "Diffraction along the Moon's Limb."

Of course all these methods would only be used where the application of the calculus is impossible. The true test of the excellence of the devices here proposed is to apply them to some known series of observations, and for this purpose I have selected those of Regnault on the latent heat of steam, its pressure, and on the absolute dilatation of mercury.

I. *Latent Heat of Steam.*—Four series of experiments were made, and from them he concluded that the total heat was best represented by the formula $T = 606{\cdot}5 + {\cdot}305t°$. I therefore assumed this as a first approximation, and constructed points as in Plate I. in which temperatures are measured horizontally and the total heat vertically, the unit of the latter being ten times that of the former.

Series I. is confined to determinations very near 100°. Six preliminary experiments give the points represented by crosses. The other 38 are contained between 638·3 and 635·5 or + 1·3 and — 1·5. The square shows the mean of the latter which is 636·73, the circle the mean of the whole 44, or 636·35. The probable errors of these means are ·09 and ·13. The formula giving 637 is evidently too great.

Series II. relates to temperatures between 100° and 200°. The formula again gives too large results.

Series III. gives the measurements between 50° and 100°. With a single exception every point is below the axis.

Series IV. for low temperatures (near 0°) gives very scattering results. They are, however, in general above the axis.

If we simplify the formula of Regnault by substituting ·3 for ·305, so that it shall read $T = 606{\cdot}5 + {\cdot}3t$, we obtain the line A C, which agrees much better with the observations of series I., II. and III., and nearly as well with series IV. Its agreement with series I. is all that could be desired, being less than the mean, if we reject the first six observations, and greater than it, if we retain them. Giving them a weight of ·7 makes the mean coincide precisely with our formula. To show with greater certainty the advantage gained by the change here proposed, I have computed the probable errors regarding the old and new formulas successively as correct.

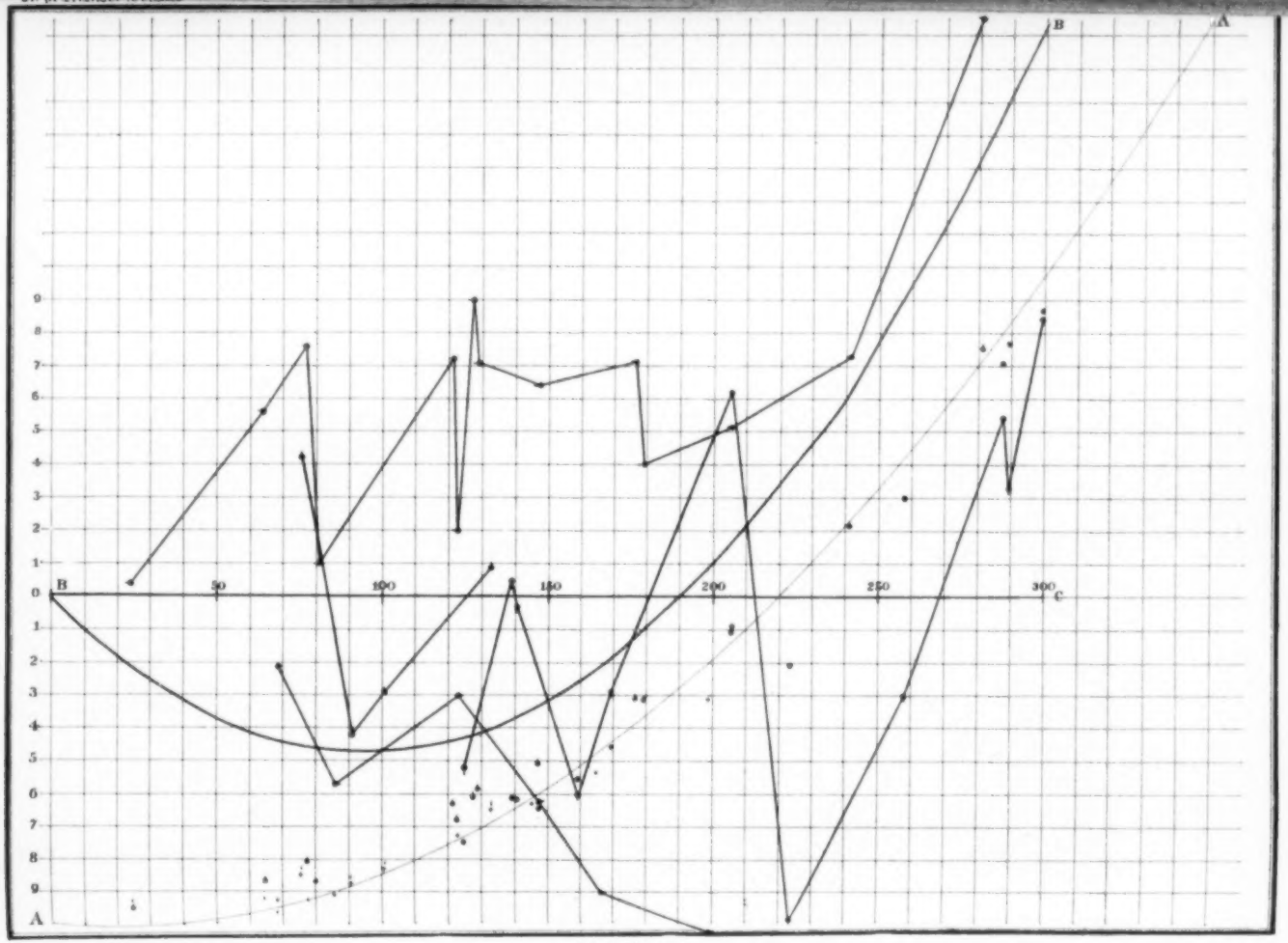
Series.	I.	I.	II.	III.	IV.	Alk
Number observations.....	38	44	73	23	22	156
Probable error, Regnault's formula.....	·55	·87	1·27	2·00	3·15	1·72
Probable error, proposed formula	·53	·74	1·07	1·77	3·15	1·60

The probable errors according to the new formula being evidently less than the others we conclude that the total heat of steam may be expressed by the formula:—

$$T = 606{\cdot}5 + {\cdot}3\ t,$$

and that the total heat at the boiling point is 636·5 instead of 637 as commonly taken.

II. *Absolute Dilatation of Mercury.*—Regnault gives as the best formula for the absolute increase of volume of mercury by heat. $I = {\cdot}0001790\ t + {\cdot}000002523\ t^2$, in which I is the *increase* of volume and t the temperature. I first assumed the simple equation $I = {\cdot}0018\ t$, and constructed differences to a scale 176 times that of Regnault, (A A, Pl. II.) The points followed approximately a parabola with vertex at the origin, showing that it was necessary to take into account the second power of t. My second approximation therefore was $·000002\ t^2$, which gives a result represented in Plate II. I was now



Lith. Jas. McGuigan, Phila.

enabled to enlarge 10 times more than before, or 1760 times, which corresponds to a unit about a mile in length. That is, if one column of mercury was one mile long its change in volume would be shown in its true dimensions. The points of each series of observations are connected together giving four zigzag lines for the four series. The curved line B B shows the values computed by Regnault's formula. Series I. is evidently better satisfied by the new formula as every point falls above the curved line. Series II., on the other hand, agrees best with the formula of Regnault. Series III. and IV. agree much better with the axis except for temperatures above 270°. Although there is much uncertainty attending this measurement, yet there seems for these points a decided tendency to rise above the axis.

Computing as before the probable errors, we have:—

Series.	1	2	3	4	All.
Number of observation	4	6	11	14	35
Regnault's formula	3·4	3·8	5·4	5·6	5·1
Proposed formula	2·2	4·5	3·7	5·0	4·3

The unit is ·00001. We see then that every series except the second gives a less probable error, while the much greater ease of computing with, or remembering the new formula is obvious if we write one below the other thus:—

Regnault's formula, $I = \cdot0001790\ t + \cdot000002523\ t^2$.
Proposed formula, $I = \cdot00018\ t + \cdot000002\ t^2$

If we take our unit of temperature 100° instead of 1° we have $I = \cdot018\ t + \cdot02\ t^2$.

III. *Pressure of Steam.*—The principal object of Regnault's researches was to determine this law. He drew a smooth curve through his observed points, and then compared it with several empirical formulas. As he gives the differences in numbers it is difficult to compare them with one another. I have therefore constructed points in Pl. III. in which the horizontal distances represent temperatures, vertical distances, the difference in pressure computed by the formula and that given by the curve. The unit is 1 mm., and the scale below 100° ten times that above.

The exponential formula of Biot was first tried. Log. F $= a + b\,\alpha^{x} + c\,\beta^{x}$, in which F is the pressure, x the temperature plus a constant. In equation (F) which relates to temperatures above 100°, $x = T - 100$, in (H) $x = T + 20$, and applies to all temperatures. M. Roche proposed the formula $F = a\,\alpha^{1 + \frac{x}{m\,x}}$ founded on theoretical considerations and represented by K. The deviation here being greater, the exponential formula was adopted, and by it the common table for the pressure of steam was computed. It will be noticed that certain irregularities are common to all, for instance, at 150° and 200°. These were evidently due to the impossibility of constructing graphically a perfectly smooth curve. As, moreover, the deviation in many cases amounts to one centimetre we see that even the third place of decimals is sometimes doubtful.

The above examples show that it is perfectly possible thus to render obvious the errors even in the most accurate series of experiments, while from a curve we are able to judge with far more certainty of the nature of the errors and the best means of diminishing them, than it is possible to do from the numerical results.

Mass. Inst. of Technology, Nov. 1st, 1870.

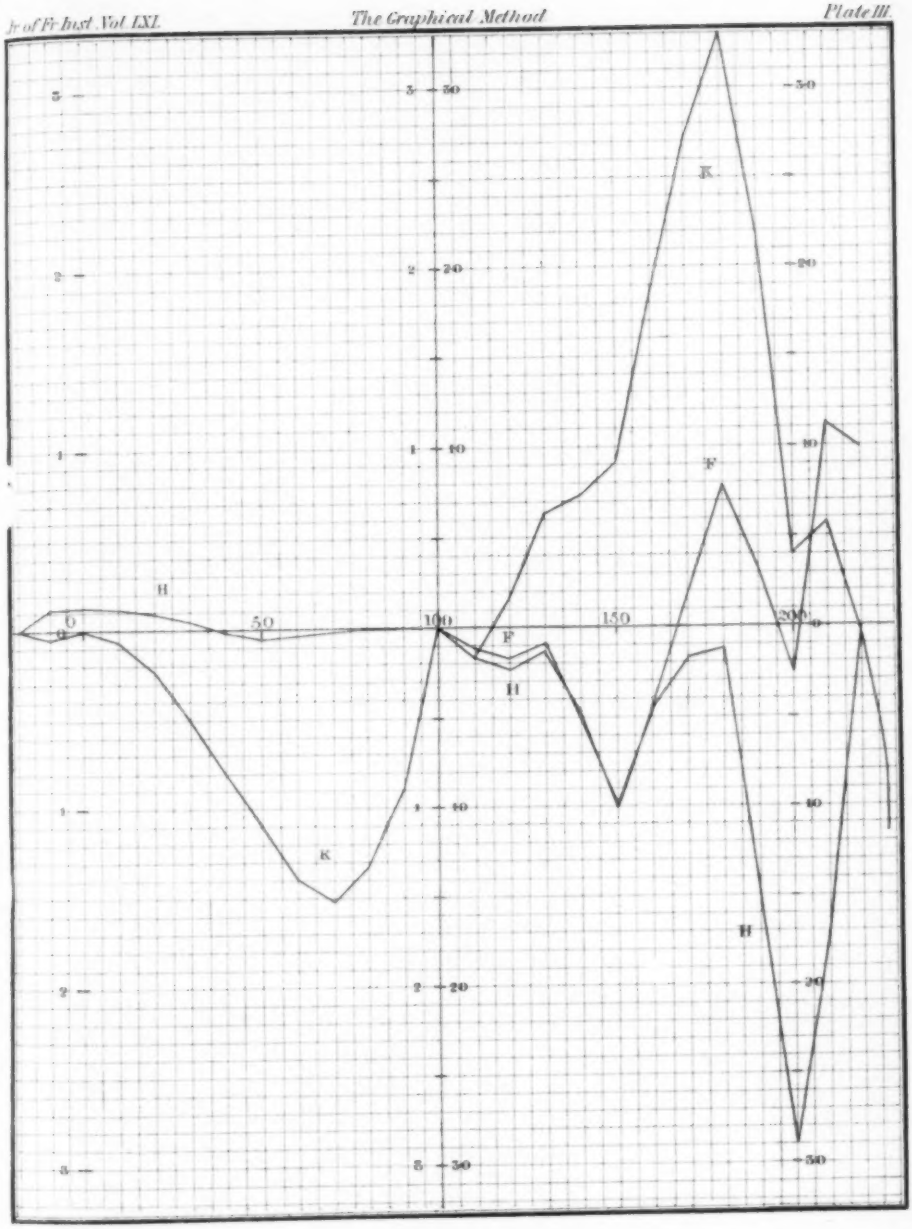
ON THE COMPOSITION OF THE SHELL OF THE LINGULA PYRAMIDATA.

By Charles P. Williams, Professor of Chemistry, Delaware College.

In 1854, Dr. T. Sterry Hunt first showed * that the shells of the Lingulæ were composed mainly of calcic-phosphate, and that, at least so far as their cinereal ingredients were concerned, they had a composition closely approximating to that of the bones of the vertebrata. The probable relation of fossil species of this genus to the phosphatic nodules found in the oldest members of the Silurian rocks of Canada, was also pointed out by the same chemist. Recently, Prof. W. C. Kerr, Geologist to North Carolina, has ascribed† the origin of the material of the interesting and commercially important deposits of South Carolina, to an existing species of same genus. This species is the *Lingula Pyramidata*, now living in the

* Am. Jour. Science (2) XVII, page 235.

† In a paper read before the American Association, at its August (1870) meeting—an abstract being given in the *American Chemist*, Nov., 1870, p. 180.



Lith. by M. Geiger, Phila.

shoals along the coasts of North and South Carolina, and having, according to the last named observer, a habitat at the precise level Ashley phosphates.

Some months since, through the kindness of Mr. Geo. T. Lewis, of Philadelphia, I received several specimens of this interesting brachiapod, and have completed two analyses of a sample of their shells. The specimens were from Beaufort Harbor, N. C. The average weight of the detached shells and adhering membrane, in their fresh state, was 0436 grammes. The samples were carefully dried at 100° C., and the analyses were conducted in the following manner: The organic matters were estimated by incineration and subsequent moistening with carbonate of ammonia and ignition. The hydrochloric acid solution was treated with ammonia and acetic acid, for the precipitation of the ferric phosphate and fluoride of calcium; in the filtrate acidulated with acetic acid, the lime was thrown down as an oxalate, but subsequently converted into and weighed as a sulphate; the magnesian phosphate precipitated in the filtrate by the addition of ammonia, and finally the remaining phosphoric acid separated by adding the magnesian solution. This last precipitate was dissolved, and re-precipitated and weighed in the usual manner. The first precipitate, by ammonia and acetic acid, was analyzed for fluoride of calcium, and separate samples were taken for the carbonic acid and for the sulphate of lime, etc., soluble in water. Annexed are the results:

	I.	II.	Mean.
Organic matters,	41·093	41·580	41·336
$3\,CaO\,PO_5$,	50·753	49·927	50·340
$3\,MgO\,PO_5$,	5·064	5·314	5·189
$3\,FeO\,PO_5$,	trace.	trace.	trace.
Ca Fl.,	·975	·790	·882
$CaO\,CO_2$,	2·411	2·607	2·509
$CaO\,SO_3$,	·208	·098	·153
Chlorides,	traces.	traces.	traces.
Insoluble in acids,	·183	trace.	·091
	100·687	100·316	100.501

In Dr. Hunt's analysis of a specimen of the *Lingula ovalis*, 0·186 grammes lost by calcination 0·072 grammes, which corresponds to 39·24 per cent. of organic matters. The ash gave him 85·79 per cent. of tri-calcic phosphate, which, calculated to the original shell, would give 52·12 per cent.—a result not differing materially from

that obtained by myself for the Lingula pyramidata, and both showing a close approximation in the shell of this brachipod to that of human bone. No estimation was made of fluoride of calcium by Hunt, but in the species analyzed by me the relation existing in apatite, between this substance and the phosphate of lime, was not obtained.

From among the many complete analyses of the Charleston phosphate I have from time to time made, the following (I) is selected for comparison with the result (II) obtained by Hunt, in an analysis of a rounded mass, of a yellowish color, from the Chazy limestone of Hawkesbury, containing fragments of a fossil Lingula, and which had probably resulted from this:

	I.		II.
3 CaO PO_5,	60·47		44·71
3 Mg O PO_5,	2·38	Mg O CO_2,	4·76
Al_2 O3 + Fe_2 O_3,	2·08		8 60
Ca Fl,	·70		
CaO CO_2,	8·34		6·60
CaO SO_3,	2·89		
Na Cl,	·62		
Organic matters,	8·56		5·00
Insoluble Silicious Matters,	12·27		27·96
	98·31		97·56

These results, compared with the composition of the possible sources of the materials—the Lingulæ—show that in the process of fossilization the phosphate of lime is not concentrated, but is rather diminished, it may be, either by solution through the agency of the decomposition of the nitrogenous organic matters of the recent specimens, or by decomposition through carbonic acid and subsequent solution. S. P. Sharples, * in commenting upon his analyses of rocks, bearing some analogy to the Charleston phosphates, but obtained by dredging from the Gulf Stream, suggests this same change in the direction of loss of phosphate of lime, and states that the more recent the bone the more abundant the phosphoric acid. Admitting this, the diminished amount of calcic-phosphate in the Charleston material cannot be regarded as militating against the view that its origin may be due to the comminution, alteration and agglomeration of the shells of the Lingula now inhabiting the shoal waters of the coast of North and South Carolina The persistance of these

* Am. Jour. Sciences. March, 1871.

brachipods through all geological periods, from the Potsdam sandstone upwards, in connection with the composition of their testaceous coverings, may give them a significance in the genesis of phosphatic nodules and minerals, not now admitted. They may at least suggest the inquiry in how far other recent deposits of the so-called phosphatic guanos, such as are found on Navassa, Swan, and Sombrero islands may originate from the remains of other Molluscous animals with shells of a composition similar to the Lingulæ.

Newark, Delaware, March 13, 1871.

ON THE USE OF HYDRAULIC MORTAR.

[Translated from "Die hydraulischen Mörtel" of Dr. W. Michaëlis, for the Journal of the Franklin Institute.]

By Adolph Ott

It is the peculiarity of all hydraulic mortar, that it hardens under the influence of water, and becomes almost wholly insoluble in the same; it is therefore necessary to make use of it wherever a construction is exposed to the destructive agency of that element, either continually or from time to time.

Hence, this mortar is one of the most essential requisites for all hydraulic constructions, as it would be impossible to erect a durable building under water without having recourse to this cement, unless the use of mortar be abstained from altogether, and large and carefully prepared building stone used instead, which would not require any cementing whatever.

The enormous cost and the difficulties of the latter method would most undoubtedly reduce the number of such constructions to a minimum, and when, for instance, we now see imposing lighthouses boldly defying the threatening pressure of the waves, the mariner might be exposed to all the dangers of the coast without a warning signal or a guiding beacon; where splendid ports, with massive docks and bulwarks, most effectually protect trade and commerce against the indomitable nature of a powerful element, we would probably find no trace of the lively intercourse and international commerce which animate our principal seaports, had not human skill and ingenuity found means to replace by art what nature has either refused or granted only at a few exceptional places.

And even at the latter it is reserved to the hand of man to give

to these protecting agencies all the perfection of which they are susceptible.

For the security of commerce, for coast defence and protection, for the intercourse on our water roads in the interior, and for a thousand other purposes, hydraulic mortar is of the highest importance.

Far from being useful only where nature demands its application, it replaces air-mortar in most, not to say in all instances, with the best success.

This applies especially to the best descriptions of hydraulic mortar, and, above all, to the Portland cement.

The extraordinary hardness which this cement acquires in so short a time, and which, as has been proven by numerous trials and investigations in comparison with other mortars, makes the finished construction appear as if chiseled out of one block and out of one substance, as a monolite, is conclusive proof of the superior advantages of this cement over common lime mortar, wherever solidity and durability are aimed at, especially where a construction has to be finished within the shortest time possible.

Yes, we may safely assert that the use of this mortar for buildings above water has made a remarkable impression on our modern architecture, and has replaced the old stiff and clumsy masses by elegance and boldness of conception.

One need but compare the columns, arches and lofty balconies of the present day with those of former periods, to see how much more ease and freedom characterizes our modern style. It looks as if the architect knew how to inculcate his creation with his genius, yea, as if he had succeeded to free himself, as if by magic, from the fetters of gravitation, to which all matter is inevitably subjected.

This supposed magic power is nothing else but the solidity of the materials at his disposal, mortar and iron.

The first practical application of hydraulic mortar of any description was most probably made during the last century before the Christian era.

Vitruvius, to whose description of hydraulic mortar we shall hereafter refer, speaks of its use in the construction of piers and buildings in moist and swampy localities. From the time of Pliny (who reproduces the report of Vitruvius) up to the fifteenth century, no further mention is made of the use of this material.

During the fifteenth and sixteenth centuries, Leo Baptista and

Paladio Scamozzi, two Italian authors, and Philibert de Lorme, a French writer, have made precisely the same reports as Vitruvius.

Since the latter part of the seventeenth century, the Dutch, the condition of whose country renders hydraulic constructions especially desirable and necessary, have used trass, with the excellent hydraulic qualities of which they had become acquainted. Next to Holland, the application of water mortar was first resorted to in France, and then in England, but up to the middle of the eighteenth century nothing further became known about its use and application than that which had already been familiar to the Romans; for the eminent work of Bélidor ("Architecture hydraulique, Paris, 1753,") contains nothing but the directions given by Vitruvius. Since the end of the last century, however, a lively and general interest in the subject has manifested itself.

The celebrated architect, Smeaton, builder of the Edystone light-house, and author of the work published on its construction in 1791, gave a fresh impulse to the experiments with and the universal attention paid to hydraulic mortar. He had to solve the problem of constructing a high and colossal structure, exposed to the tremendous fury of the sea, for which purpose he had to look out for a mortar capable of resisting the influence of water most effectively and lastingly, in order to prevent the rapid ruin of the edifice. For this purpose the various descriptions of English lime were subjected to a careful examination, until he found that the hardening of mortar in water was solely dependent on the proportion of clay it contains: *on its argilliferousness*, and not, as Bélidor, George Semple (1776), and Dr. Higgins (1780) had assumed, on the hardness and denseness of the limestone.

The excellent qualities of Parker's mortar, introduced in 1796, and subsequently called Roman cement, but above all, the invention of artificial cement of decidedly superior efficacy (1822, Girault and St. Leger, 1824, Joseph Aspdin) more especially contributed to the introduction of the hydraulic mortar. The great advantages secured by the use of the better descriptions of these artificial cements are so indisputable that their application is calculated to become more general from day to day.

Hydraulic lime and cement, if to be used as mortar, are mixed either with sand or with some other material serving as a substitute for sand. For weak hydraulic lime, such an admixture is an essential improvement; the weakest descriptions of it would not, in fact, be

of any practical use without it, as, like common lime, they are not in themselves of sufficient solidity.

With cement it is different, however, and we need only call to mind the specific gravity, the structure and the hardness of Portland-cement to explain this.

But if even Portland-cement receives in most cases an admixture of sand, the reason of it is this, that although its hardness is no doubt considerably lessened by this process, it still remains sufficient to afford the necessary security (Portland-cement mixed with three times its quantity of sand becomes in a few months superior to air-mortar more than a hundred years old), while the cost of the material is thus evidently reduced in no small degree. It is also found that Portland-cement is worked with greater ease and security when mixed with sand.

The best admixture is undoubtedly sand. It has been used for that purpose from time immemorial, and it is indeed the best adapted material, as well on account of its nature and special quality as on account of the facility with which it can be procured almost everywhere.

The circumstance that the hardness of any mortar prepared with sand is dependent on the greater or smaller adhesion of the lime or cement to the sand, shows conclusively, that not every kind of sand is fit for the preparation of mortar; that its adaptability for that purpose is dependent on the condition of its surface, on its form and cleanliness. As far as the cohesion of the sand is concerned, clean quartz-sand is preferable to all others, on account of its greater solidity and of its greater power of resistance to the decomposing influence of the weather. From a chemical point of view, however, an admixture of feldspar or other mineral debris, upon which lime exercises its action, however slowly, might be recommended, inasmuch as they cause a slow but constant increase of the firmness of the material, especially when weak hydraulic lime has been chosen.

At Havre, for instance, they use almost exclusively sand composed of flint-detritus, because it has been found that it makes a far better mortar than any other material.

Surfaces which are covered with light dust or with loose claymire always form a great impediment to intimate, close cementing. It is well known that scarcely more than five per cent. of clay are sufficient to reduce the hardening capacity of ordinary lime mortar to a minimum. It is therefore necessary to resort to a careful

washing of all sand which is to be used for the preparation of mortar, and which is not in itself very clean, until the water runs off clear. Sand taken from the bed of a river and sea-sand have gone through such a washing process to an extensive degree; these sands are consequently very clean in most cases, and would therefore be extremely well fitted for our purpose, if they had not been ground into smooth round granules through the constant influence of the moving water. Now, it is well known that bodies of a spherical form offer the smallest surface proportionately, and that an aggregate of such globules contains the largest intermediate space. Such sand is therefore of but very little use when we have to look above all to the greatest possible surface, and to the smallest measure of interstices. For this reason, clean, angular and irregularly shaped pit-sand may be considered the best admixture, especially where its surface is largest in proportion to its quantity, and where it almost assumes the form of leaflets, such as are obtained by the splitting of minerals.

As it is desirable that the extent of surface be proportionately larger than the quantity of the sand, fine sand is always preferable to coarse; the latter should never be used alone, but should always be mixed with a sufficient proportion of fine sand to fill up, as far as this can be done, the intermediate space between the coarse granules.

The quantity required for this purpose can easily be ascertained by taking a certain volume of coarse sand, one hectolitre for instance, and by pouring into it water out of a gauged vessel, or from a weighed quantity, until all the intermediate space is filled up, and the water begins to show itself at the surface. The quantity of water used indicates the aggregate intermediate space in the coarse sand. By proceeding in the same manner with the fine sand intended for admixture, the difference in the volume of water used shows the quantum of fine sand required to fill out the interstices in the coarse material. But wherever fine sand can be easily obtained at small expense, such particular measuring may be done away with, as it is better to take at random a larger quantity for admixture.

Coarse sand may be used in larger proportions where solidity and compactness are not especially aimed at; in the construction of foundations gravel and stone debris answer the purpose.

The quality of sand may be easily ascertained as follows:

If good sand is rubbed between the hands, its roughness is felt, and a grating sound is heard.

If spread on white paper or linen, and rubbed smooth, no dirty spots or stains should be visible on the paper or linen.

If shaken in a glass of water, the latter ought not to appear materially troubled.

(To be continued.)

Franklin Institute.

Proceedings of the Stated Meeting, January 18th, 1871.

THE meeting was called to order with the President, Mr. Coleman Sellers, in the chair.

The minutes of the last meeting were read and approved.

The Actuary submitted the minutes of the Board of Managers, and reported that at their stated meeting, held January 14th, donations to the Library were received from the Royal Institution of London, l'Academie des Sciences, of Paris; the Geologischen Reichsanstalt of Vienna, Austria; the Literary and Historical Society of Quebec, Canada; Col. J. B. Eads, Chief Engineer of the Illinois and St. Louis Bridge, St. Lous, Mo.; Prof. J. C. Coffin and the Surgeon General's Office, Washington, D. C.; Gen. W. W. Wright, Leavenworth, Kansas; and from Wm. Q. Wharton, Phila.

It was further reported that Samuel Hart and Wm. B. Bement had resigned their membership in the Board of Managers, and the annual report of the Board to the Institute was read.

The Judges of election for the year 1871 here reported that the balloting had resulted in the choice of the following gentlemen as officers, to wit:

For President, Coleman Sellers.

For Vice-President, Robert E. Rodgers.

For Treasurer, Frederick Fraley.

For Secretary, Wm. H. Wahl.

Managers, for three years, Wm. B. Le Van, Jacob Naylor, Samuel Sartain, Chas. Bullock, Enoch Lewis, Wm. Helm, R. Egglesfield Griffith, Ed. H. Williams.

For two years, Hector Orr and Clarence S. Bement.

For Auditor, Wm. Biddle.

The President expressed his gratification at the compliment of re-election and announced the reading of a paper upon the Modes of Determining of Horse Power by Edward Brown.*

The paper provoked considerable discussion participated in by Messrs. Briggs, Le Van and Brown. On motion of the last named gentleman a committe of five was appointed by the President, to in-

* For Abstract of this paper see Vol. LXI., page 187.

vestigate the subject of the paper and to report if possible upon a uniform plan to be followed in the estimation of H. P. The committee consisted of Messrs. Brown, Briggs, Le Van, Cooper, Wahl.

The report of the Secretary on novelties in sciences and the mechanic arts was next read, after which Prof. Morton exhibited a variety of wave and cohesion figures in his newly devised vertical lantern.

The meeting was then adjourned.

WM. H. WAHL, *Secretary.*

Bibliographical Notices.

Explosion of Steam Boilers. By J. R. Robinson, Steam Engineer. Little, Brown & Co. Boston, 1870.

Mr. Robinson's little book gives us accounts of boiler explosions when caused by low water, overpressure, defect in materials, sediment, and repulsion and overheating of the water in the boiler, and tells us how explosions from these several causes may be prevented. He presents to us some of those "wonderful manifestations of the power of the repulsive action of heat upon water, and of the explosive force of the sudden vaporization of water on the bottom of a steam boiler," witnessed by him during recent experiments, which throw some light upon the dark side of this mysterious subject, and which "also show how a strong steam boiler may be caused to explode at or below the ordinary working pressure, without a sign of trouble with the water noticeable at the surface up to the time of the explosion, and without an elevation of the temperature of the boiler that it would be possible to detect by the most careful examination afterwards," which fact is truly alarming, and the announcement of which should start us at once in search of a remedy.

Mr. Robinson's "report," in a few words, but deserved ones, is written by an intelligent practical man, without spread or bias, and is a clear presentation of facts which have been collected from first-class authorities and from his own experiments, as well as of conclusions drawn from these.

It deserves careful reading and consideration, as the boiler does